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OPERATIONAL CALIBRATION OF THE CIRCULAR-RESPONSE OPTICAL-MARK-READER ANSWER SHEETS FOR THE ARMED SERVICES VOCATIONAL APTITUDE BATTERY (ASVAB)

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NOTE

This report, covering the *OPERATIONAL CALIBRATION OF THE CIRCULAR-RESPONSE OPTICAL-MARK-READER ANSWER SHEETS FOR THE ARMED SERVICES VOCATIONAL APTITUDE BATTERY (ASVAB)*, has been produced in two sections to facilitate review.

The front section contains the preface, the executive summary, the text that discusses the procedures and analyses, the appendixes, and a list of references.

The second section, titled the *ASVAB OMR OPCAL SUPPLEMENT*, contains all tables and figures that provide information to support the discussion of procedures and analyses.

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PREFACE

The completion of this work would not have been possible without the efforts of many persons at the Defense Manpower Data Center (DMDC) and elsewhere. Dr. Clarence McCormick and others in the Testing Directorate at the Military Entrance Processing Command provided both leadership and day-to-day assistance in the conversion of that Command's test-scoring system to one that meets state-of-the-art standards of performance. Dr. Michael Kolen, American College Testing Program, and Drs. Neil Dorans and Linda Cook, both at Educational Testing Sevice, provided extensive information about operational equating practices at their respective organizations. Dr. Lauress Wise, Director of the DMDC Personnel Testing Division, provided invaluable counsel and energetic support during the production of a final report. Dr. John Welsh, Chief of the DMDC Test Development Branch, and Mr. Paul Foley, a staff member of the Navy Personnel Research and Development Center, provided careful and thoughtful reviews of an earlier draft of the report. And Ms. Gretchen Glick of DMDC contributed a disciplined editorial eye and a well-honed sense of style to the final editing of the report.

Special recognition must be made of the contributions of Dr. D.R. Divgi, Center for Naval Analyses. This project was the first equating study conducted completely at DMDC. Through his generous and extensive counsel on the data analysis plans and procedures throughout the project, Dr. Divgi provided DMDC with invaluable support by sharing with the authors the benefits of his keen analytic insights and his extensive experience with equating and related statistical issues.

EXECUTIVE SUMMARY

The Armed Services Vocational Aptitude Battery (ASVAB) is a set of tests administered to two separate groups of American youth: (a) all applicants for active-duty enlistment in any of the United States Armed Services, and (b) over one million high school and postsecondary students each year as part of the U.S. Department of Defense Student Testing Program.

The battery produces ten test scores, plus a verbal score which is the sum of scores from two tests and which is included in many analyses and applications. Various combinations of the test scores form composites that are used by the Department of Defense and the Services for determining eligibility for enlistment and classification into military occupations. Composites of test scores are also used for career exploration in the Student Testing Program.

In 1992, the U.S. Military Entrance Processing Command (USMEPCOM) purchased and installed new optical-mark readers (OMRs) for scanning all ASVAB operational answer sheets at its headquarters and at all the Military Entrance Processing Stations (MEPSs). These OMRs were not capable of scanning the existing answer sheets that had vertical response spaces on them, so a new type of answer sheet--one using a closed-circle answer format--had to be developed to be used with the new OMRs.

Previous to the study reported here, Ree and Wegner (1990) conducted a randomized-groups experiment in which one group of military applicants took just the ASVAB speed tests, Numerical Operations (NO) and Coding Speed (CS), using an answer sheet with circular-response spaces, and another group took the same tests using the vertical-response operational answer sheet. Their results showed that scores from the vertical-response answer sheet had *higher* mean numbers of correct answers on both tests. On NO, the effect size (mean difference divided by the normative standard deviation) was 0.36; on CS, the effect size was 0.11. Although Ree and Wegner offered no interpretation for these results, a possible explanation is that, on paper-and-pencil tests of speed, filling a small, enclosed (circular) response space required more motor control and, therefore, examinees took longer to fill in the circle than they did to fill in the unbounded response space of the kind found on the vertical-response answer sheet.

On the basis of the results obtained by Ree and Wegner (1990), it was expected that use of the circular-response answer sheets by USMEPCOM would result in speed test scores which were lower, on the average, than the scores obtained from the use of the vertical-response answer sheets. If this were to occur, and if the circular-response answer sheets were placed into operational use without an adjustment in the calibration of the test score scales, then the scores of military applicants on the occupational composites using speed tests would be reduced; this, in turn, would result in too few persons being considered eligible for classification into occupations which use those composites.

The study presented in this report had four purposes:

- The first was to assess whether, and by how much, the ASVAB test score scales differed between the circular-response and vertical-response answer sheets. This purpose was addressed for both the speed and non-speed (power) tests. Answer-sheet effects similar to those obtained by Ree and Wegner (1990) were expected in this study because of the similarity of the circular answer formats used in their study and in this study. Answer-sheet effects were not expected on the power tests because the number of items to be answered per unit of allowed time was much

smaller than on speed tests, considerably reducing the influence of variation in the time required to fill in the answer spaces. However, the power tests were investigated as a precautionary step. If answer-sheet effects were present on the power tests, and if the score scales of these tests were not appropriately adjusted to incorporate the effects, then inaccuracies could be introduced into both the Armed Forces Qualification Test (AFQT) composite used for military selection and the composites used for classification into military occupations.

- The second purpose of this study was to develop any conversion table adjustments that would be necessary when the circular-response answer sheets were placed into operational use. Tests with answer-sheet effects would require an adjustment in the tables used to convert number-right scores into standard-score equivalents in the norming population, the 1980, 18-to-23-year-old Youth Population (U.S. Department of Defense, 1982). Because not all forms of the ASVAB use the same conversion tables with the vertical-response answer sheet, the adjusted conversion tables would also differ across forms.

- The third purpose was to provide at least a partial check of the effects of any conversion table adjustments on the distributions of the AFQT and occupational composites. If the subtest conversion tables were adjusted correctly for the use of circular-response answer sheets, the resulting distributions of composite scores would be quite similar across answer sheets.

- The fourth purpose of this study was to assess whether, and by how much, the ASVAB test score scales differed between the circular-response answer sheet used to test military applicants in the Enlistment Testing Program and the circular-response answer sheet used in the Student Testing Program. Both answer sheets have the circular-response format, but the block of response spaces for the CS test is in the middle of the page for the Enlistment Testing Program (because the answer sheet has space for background information to be entered at the top of the page), compared to the Student Testing Program CS response spaces which are situated on the top of the page. Although this difference was not expected to create any answer-sheet effects, such effects were investigated as a precautionary step. If answer-sheet effects were present, and if the score scales of the affected tests were not appropriately adjusted to incorporate the effects, then inaccuracies would be introduced into the scores reported in the Student Testing Program. (For those who use their Student Testing Program ASVAB scores for military enlistment, inaccuracies could also be introduced into the AFQT composite used for military selection and the composites used for classification into military occupations.)

This study was conducted in two phases:

- For the first phase, the circular-response and vertical-response answer sheets were used to administer the ASVAB to randomly equivalent groups of approximately 3,000 military recruits. Both types of answer sheet were in the format to be used in the Enlistment Testing Program, not the Student Testing Program. The recruits were in an early stage of basic training for active duty in the Army, Navy, Marine Corps, and Air Force and were administered the test battery non-operationally (i.e., the scores were not to be made a part of their personnel record nor used for training or job assignment).

The goal of the first phase was to address the first three purposes of the study: (a) assess differences between the effects of the circular-response and vertical-response answer sheets, (b) develop any necessary adjustments in the ASVAB test conversion tables for the circular-response answer sheets, and (c) obtain a partial check of the effects of the conversion table adjustments

on the distributions of composites.

- In the second phase, the circular-response answer sheet for student testing and the circular-response answer sheet for enlistment testing were used to administer the ASVAB to randomly equivalent groups of approximately 250 military recruits. As in the first phase, the recruits were in an early stage of basic training for active duty and were administered the test battery non-operationally.

  The goal of this phase was to assess differences in the effects of the circular-response student answer sheets and the circular-response enlistment answer sheets.

The ASVAB 13c form was used for both phases of the study. Except for its cover, this form is equivalent to the ASVAB 8a, the reference form which was used to collect the normative data in 1980 (U.S. Department of Defense, 1982). The answer-sheet effects obtained with the use of this form were assumed to be the same as answer-sheet effects that would be obtained with the use of other ASVAB forms. This assumption was the basis for using results from the ASVAB 13c in this study to adjust the conversion tables of other the ASVAB forms for the IOT&E. In a later study, analyses of data collected in the IOT&E were conducted to provide a check of the assumption.

The subjects in both phases of this study were active-duty recruits in basic training at Army, Navy, Marine Corps, or Air Force Recruit Training Centers and Depots during the months of April, May, and June, 1990.

The results of this study indicated that use of the circular-response answer sheet with speed tests of the ASVAB produces lower scores than does use of the vertical-response answer sheet. The results further indicated no difference between use of the two answer sheets with the power tests. The direction and magnitude of the effects on speed tests were consistent with the direction and magnitude of the differences found earlier by Ree and Wegner (1990) between the circular-response answer sheet used in norming the ASVAB and the vertical-response answer sheet used for operational testing at the time of the present study. In Phase II, the results indicated no differences between the use of the circular-response answer sheets for the student and enlistment ASVABs.

The results of this study also included conversion tables to be used when the circular-response answer sheet is used along with the ASVAB 15/16/17 in the Enlistment Testing Program and the ASVAB 14 and 18/19 in the Student Testing Program. The tables were developed for operational use in an Initial Operational Test and Evaluation (IOT&E) of the circular-response answer sheets and, if necessary, after the IOT&E until analyses of the IOT&E data provide alternative tables. It was assumed that adjustments would be made in all of these conversion tables subsequent to analyses of data from the IOT&E of the circular-response answer sheets; unlike the analyses used to develop the tables presented here, analyses of the IOT&E data would be based on samples which are representative of the full distribution of applicants for Military Service.

OPERATIONAL CALIBRATION OF THE CIRCULAR-RESPONSE OPTICAL-MARK-READER ANSWER SHEETS FOR THE ARMED SERVICES VOCATIONAL APTITUDE BATTERY

INTRODUCTION

The Armed Services Vocational Aptitude Battery (ASVAB) is a set of tests administered to two separate groups of American youth: (a) all applicants for active-duty enlistment in any of the United States Armed Services, and (b) over one million high school and postsecondary students each year as part of the U.S. Department of Defense Student Testing Program.

The test battery produces a score for each of the ten tests listed in Table 1 (see the *ASVAB OMR OPCAL Supplement*, p. S-1), plus an eleventh score, Verbal (VE), which equals the sum of scores from two of the tests, Word Knowledge (WK) and Paragraph Comprehension (PC). Various combinations of the test scores form composites that are used by the Department of Defense and the Services for determining eligibility for enlistment and classification into military occupations. Composites of test scores are also used for career exploration in the Student Testing Program.

In 1992, the U.S. Military Entrance Processing Command (USMEPCOM) purchased and installed new optical-mark readers (OMRs) for scanning all ASVAB operational answer sheets at their headquarters and at all the Military Entrance Processing Stations (MEPSs). These OMRs were not capable of scanning the existing answer sheets that had vertical response spaces on them (see Figure 1 in the *Supplement*, pp. S-57 through S-60), so a new type of answer sheet--one using a closed-circle answer format (see Figure 2 in the *Supplement*, p. S-61 through S-64)--had to be developed to be used with the new OMRs.

Previous to the study reported here, Ree and Wegner (1990) conducted a randomized-groups experiment in which one group of military applicants took the ASVAB speed tests, Numerical Operations (NO) and Coding Speed (CS), using an answer sheet with circular-response spaces, and another group took the same tests using the vertical-response operational answer sheet. Their results showed that scores from the vertical-response answer sheet had *higher* mean numbers of correct answers on both tests. On NO, the effect size (mean difference divided by the normative standard deviation) was 0.36; on CS, the effect size was 0.11. Although Ree and Wegner offered no interpretation for these results, a possible explanation is that, on paper-and-pencil tests of speed, filling a small, enclosed (circular) response space required more motor control and, therefore, examinees took longer to fill in the circle than they did to fill in the unbounded response space of the kind found on the vertical-response answer sheet.

On the basis of the results obtained by Ree and Wegner (1990), it was expected that the circular-response answer sheets to be used by USMEPCOM would result in speed test scores which were lower, on the average, than the scores obtained from the use of the vertical-response answer sheets. If

this were to occur, and if the circular-response answer sheets were placed into operational use without an adjustment in the calibration of the test score scales, then the scores of military applicants on the occupational composites using speed tests would be reduced; this, in turn, would result in too few persons being considered eligible for classification into occupations which use those composites.

The study presented in this report had four purposes:

- The first was to assess whether, and by how much, the ASVAB test score scales differed between the circular-response and vertical-response answer sheets. This purpose was addressed for both the speed and non-speed (power) tests. Answer-sheet effects similar to those obtained by Ree and Wegner (1990) were expected in this study because of the similarity of the circular answer formats used in their study and in this study. Answer-sheet effects were not expected on the power tests because the number of items to be answered per unit of allowed time was much smaller than on speed tests, considerably reducing the influence of variation in the time required to fill in the answer spaces. However, the power tests were investigated as a precautionary step. If answer-sheet effects were present on the power tests, and if the score scales of these tests were not appropriately adjusted to incorporate the effects, then inaccuracies could be introduced into both the Armed Forces Qualification Test (AFQT) composite used for military selection and the composites used for classification into military occupations.

- The second purpose of this study was to develop any conversion table adjustments that would be necessary when the circular-response answer sheets were placed into operational use. Tests with answer-sheet effects would require an adjustment in the tables used to convert number-right scores into standard-score equivalents in the norming population, the 1980, 18-to-23-year-old Youth Population (U.S. Department of Defense, 1982). Because not all forms of the ASVAB use the same conversion tables with the vertical-response answer sheet, the adjusted conversion tables would also differ across forms.

- The third purpose was to provide at least a partial check of the effects of any conversion table adjustments on the distributions of the AFQT and occupational composites. If the subtest conversion tables were adjusted correctly for the use of circular-response answer sheets, the resulting distributions of composite scores would be quite similar across answer sheets.

- The fourth purpose of this study was to assess whether, and by how much, the ASVAB test score scales differed between the circular-response answer sheet used to test military applicants in the Enlistment Testing Program and the circular-response answer sheet used in the Student Testing Program. Both answer sheets have the circular-response format, but the block of response spaces for the CS test is in the middle of the page for the Enlistment Testing Program (because the answer sheet has space for background information to be entered at the top of the page), compared to the Student Testing Program CS response spaces which are situated on the top of the page. (See Figure 2 on pp. S-61 through S-64 and Figure 3 on pp. S-65 through S-67 in the *Supplement*.) Although this difference was not expected to create any answer-sheet effects, such effects were investigated as a precautionary step. If answer-sheet effects were present, and if the score scales of the affected tests were not appropriately adjusted to incorporate the effects, then inaccuracies would be introduced into the scores reported in the Student Testing Program. (For those who use their Student Testing Program ASVAB scores for military enlistment, inaccuracies could also be introduced into the AFQT composite used for military selection and the composites used for classification into military occupations.)

DESIGN

This study was conducted in two phases:

- For the first phase, the circular-response and vertical-response answer sheets were used to administer the ASVAB to randomly equivalent groups of approximately 3,000 military recruits. Both types of answer sheet were in the format to be used in the Enlistment Testing Program, not the Student Testing Program. The recruits were in an early stage of basic training for active duty in the Army, Navy, Marine Corps, and Air Force and were administered the test battery non-operationally (i.e., the scores were not to be made a part of their personnel record nor used for training or job assignment).

  The goal of the first phase was to address the first three purposes of the study: (a) assess differences between the effects of the circular-response and vertical-response answer sheets, (b) develop any necessary adjustments in the ASVAB test conversion tables for the circular-response answer sheets, and (c) obtain a partial check of the effects of the conversion table adjustments on the distributions of composites.

- In the second phase, the circular-response answer sheet for student testing and the circular-response answer sheet for enlistment testing were used to administer the ASVAB to randomly equivalent groups of approximately 250 military recruits. As in the first phase, the recruits were in an early stage of basic training for active duty and were administered the test battery non-operationally.

  The goal of this phase was to assess differences in the effects of the circular-response student answer sheets and the circular-response enlistment answer sheets.

The ASVAB 13c form was used for both phases of the study. Except for its cover, this form was equivalent to the ASVAB 8a, the reference form which was used to collect the normative data in 1980 (U.S. Department of Defense, 1982; normative means and standard deviations in Table 1; see *Supplement*, p. S-1). The answer-sheet effects obtained with the use of this form were assumed to be the same as answer-sheet effects that would be obtained with the use of other ASVAB forms. This assumption was the basis for using results from the ASVAB 13c in this study to adjust the conversion tables of other the ASVAB forms for the IOT&E. In a later study, analyses of data collected in the IOT&E were conducted to provide a check of the assumption.

METHOD

SUBJECTS

The subjects in both phases of this study were active-duty recruits in basic training at Army, Navy, Marine Corps, or Air Force Recruit Training Centers and Depots during the months of April, May, and June, 1990. Table 2 (see *Supplement*, p. S-2) shows the dates of testing, and the number of subjects tested are shown by Service, location, and type of answer sheet for each of the two phases of the study. These numbers are based on manual counts of the answer sheets as they were received for processing.

PROCEDURES

Phase I

The subjects were tested in groups which varied in size according to the numbers of recruits available at the test site each day. The test administrator at each Recruit Training Center or Depot was a test control officer assigned to a department normally given the responsibility for administering personnel tests at that location. During the first few test sessions at each site, a staff member of a contractor--Human Resources Research Organization (HumRRO)--was present to monitor the test administration and review the quality-control procedures of the study (see Appendix A) with the test administrator.

Each subject was provided an answer sheet, an ASVAB test booklet, two pencils, and two pieces of scratch paper. To ensure equivalent conditions for use of the two types of answer sheets (Figures 1 and 2 in the *Supplement*, pp. S-57 through S-64), subjects in alternate seats were given the circular-response enlistment answer sheet, and the remaining subjects were given the vertical-response enlistment answer sheet. To facilitate this procedure, the two types of answer sheets were arranged alternately in the package of answer sheets provided to the test administrator for distribution to subjects.

Before the administration of the ASVAB tests, subjects were given the standard ASVAB instructions (U.S. Department of Defense, 1990) for providing the following identifying information: the date, their name, their social security number, the ASVAB test version, their sex, their education level, their Service and Component, the test site, and their population group. They also signed a Privacy Act statement (see Appendix B) on the answer sheet. The tests were then administered as specified in the standard ASVAB instructions.

At the end of each week of testing, test administrators sent the answer sheets from that week's testing to HumRRO, to be inspected for stray marks and prepared for scanning as follows:

- The circular-response answer sheets were scanned by HumRRO on a NCS OpScan 5 Model 20 OMR.

- The vertical-response answer sheets were sent to RGI, Corp., where they were scanned on a Cognitronics Model 880 single-sided-image OMR owned by the Navy.

In addition, 300 answer sheets (150 from early in the data collection, and 150 from late in the data collection) of each type were scanned a second time on a different machine at Headquarters, USMEPCOM, to check for differences across scanners, as follows:

- The circular-response answer sheets were scanned on a NCS OpScan 21 Model 100 OMR.

- The vertical-response answer sheets were scanned on a Cognitronics Model 802 OMR.

Phase II

After testing a specified number of subjects for Phase I, the test administrators at each site began the data collection for Phase II.

The procedure in Phase II was the same as the procedure for Phase I, with two exceptions:

- First, the answer sheets distributed to the subjects were the circular-response student answer sheet (see Figure 3 in the *Supplement*, pp. S-65 through S-67) and the circular-response enlistment answer sheet (see Figure 2 in the *Supplement*, pp. S-61 through S-64). These were placed in alternating order in the package of answer sheets provided to the test administrator for distribution.

- Second, even though the general test-taking instructions and test-specific instructions were the same as were used in Phase I, because of major differences in the location of identifying-information spaces on the student and enlistment answer sheets, the directions in Appendix C were used for filling in these spaces instead of the directions usually employed for ASVAB administration.

RESULTS

PHASE I

Data Quality Control and Editing

In addition to range checks, two procedures were used for data quality control and editing:

- First, for a ten-percent sample of each type of answer sheet, the item responses and test raw (number-right) scores were checked on another scanning machine.

- Second, those subjects with a substantial number of test scores below what would be expected from purely random responding were identified and excluded.

In both Tables 3 and 4 (see the *Supplement*, pp. S-3 and S-4), scanning differences appeared to be aberrantly numererous for CS on the vertical-response answer sheet. A comparison of the item-level differences for the vertical-response answer sheet revealed that 55 of the 70 differences on CS were omits (no response) in the initial scanning and answers in the scanning check; further investigation revealed an aberrant percentage of omits for items 15 (5%), 19 (5%), and 27 (4%) in the initial scanning. Because of these results, all vertical-response answer sheets were rescanned on USMEPCOM's Cognitronics Model 802, which had detected answers in place of the 55 omits in the initial scanning check of CS. The data obtained from this rescanning of the vertical-response answer sheets were used for all subsequent analyses. The rescanning changed the mean number right on each test by the amount shown in the first column of Table 5 (see the *Supplement*, p. S-5). The increase of 0.16 in the mean CS score had the same order of magnitude as the expected increase of 0.11 that would be obtained if the sample percentages of omits on items 15, 19, and 27 were replaced with correct responses.

Similarly, in both Tables 3 and 4, scanning differences also appeared to be aberrantly numerous for NO on the circular-response answer sheet. A comparison of item-level differences for the circular-response answer sheet revealed that 25 of the 30 differences on NO were omits in the initial scanning and answers in the scanning check; further investigation revealed that 10% of the cases had fewer than 30 correct responses or more than one omit in the initial scanning. Because of these results, all circular-response answer sheets for which the initial scanning produced NO scores below 30 or for which more than one omit occurred on NO were rescanned on the NCS OpScan Model 20 OMR at HumRRO; the use of a higher sensitivity setting than in the initial scanning detected 314 marks not previously detected, with 178 of these marks being on NO. For all subsequent analyses, the data obtained from the rescanning of these answer sheets replaced the data obtained from the initial scanning of them. The rescanning changed the mean number right on each test by the amount shown in the second column of Table 5. The increase of 0.05 in the mean NO score has the same order of magnitude as the expected increase of 0.08 that would be obtained if the sample prcentage of omits were replaced with correct responses.

The second procedure used for data quality control and editing was to remove all data of those subjects whose test raw scores were judged to be aberrantly low. The subjects in this study were recruits whose scores on the ASVAB had previously qualified them for military enlistment. However, because the subjects were told that their scores from this study would be of no operational consequence, a condition existed which could have resulted in very low motivation to perform well and could have, in some cases, elicited a quasi-random or stereotypic response pattern. Including the data from a substantial number of such unmotivated subjects in the analyses for this study could reduce the sensitivity of the analyses to answer-sheet effects and could impair the precision of adjustments of conversion tables. Therefore, an effort was made to identify and exclude from the analyses all data from those subjects with a substantial number of test scores below what would be expected from purely random responding. Table 6 (see *Supplement*, p. S-6) shows, for each test and for each type of answer sheet, the expected number correct from random responding and the percentage of subjects scoring at or below this level. Table 7 (see *Supplement*, p. S-7) shows, for each type of answer sheet, the distribution of the number of tests on which subjects score at or below this level.

Based on an inspection of Table 7, it was decided to remove data obtained from subjects who scored at or below the chance level on three or more tests. This resulted in the loss of data from 47/3195 = 0.015 of the subjects in the vertical-response answer sheet group and 44/3204 = 0.014 of the subjects in the circular-response answer sheet group. This was judged to provide a balance between the necessity of removing data of aberrantly low-scoring subjects and the necessity of retaining the number of data points required for developing adjustments of conversion tables. (Note: in editing the recruit-subject data set for the operational calibration of the ASVAB 18/19, the Air Force Human Resources Laboratory, 1988, also removed data obtained from subjects who scored at or below chance on three or more tests.)

Equivalence of Groups

For the data collection in Phase I, the two types of answer sheet were distributed in alternation to subjects in each testing session. This stratification of the administration was intended to provide two randomly equivalent groups of subjects: those who used the circular-response answer sheet and those who used the vertical-response answer sheet. However, if the two groups differed on characteristics in

addition to the answer sheet used to administer the ASVAB, differences in performance could be attributed to those characteristics as well as to the answer sheet. As a check on the possibility of such a confound, the two groups were compared with respect to background characteristics (i.e., gender, ethnicity, and educational level) and performance on an earlier ASVAB (i.e., an ASVAB taken prior to enlistment).

The results of these investigations indicated that the groups were sufficiently equivalent to justify proceeding with analyses of answer-sheet effects and with equating analyses. Table 8 (see *Supplement*, p. S-8) provides frequencies and percentages at each level of the background variables for each of the two answer-sheet groups. In Table 9 (see *Supplement*, p. S-9), the variables are the pre-enlistment AFQT composite and the pre-enlistment test standard scores. The pre-enlistment scores were obtained by matching social security numbers from the circular-response and vertical-response answer sheets with social security numbers on record at the Defense Manpower Data Center (DMDC). This table provides test means and standard deviations of each group, plus the t-ratios and effect-sizes based on these means; the two verbal tests are not included here because they are not used for enlistment processing other than through their raw score sum, VE.

Answer-Sheet Effects

Answer-sheet effects were analyzed separately for each of the two speed tests (NO and CS) and as a group for the other ASVAB tests. Previous results (Ree & Wegner, 1990) suggested that answer-sheet effects could be expected for each of the speed tests, but no previous results were available to indicate that answer-sheet effects could be expected for the other tests. This difference in predictions for the speed and non-speed (power) tests called for statistical tests that differ in their conceptual unit of the Type I error rate (e.g., see Kirk, 1968). Therefore, a conventional Type I error rate (alpha = 0.05) was used separately for each statistical test of answer-sheet effects on the speed tests, providing more power where there was a prior basis for alternatives to the null hypothesis. For the power tests, the conventional Type I error rate was used for the group of statistical tests of answer-sheet effects on all power tests, providing greater protection against Type I errors where there was no prior basis for alternatives to the null hypothesis.

Speed Tests. As predicted, lower average scores on NO and CS were obtained with the circular-response answer sheets than were obtained with the vertical-response answer sheets. For each of the two speed tests, the null hypothesis was that the two answer sheets would result in the same mean and variance, the same null hypothesis that is used when choosing between an identity equating and a linear equating (Dorans and Lawrence, 1989). The hypothesis was tested with a chi-square statistic (see Appendix D) based on the joint sampling distribution of the mean and variance (Rao, 1965). This procedure was used in place of conventional t-tests for means and F-tests for variances because of the skewness and kurtosis exhibited by the ASVAB tests presently used operationally (see Appendix E); skewness introduces correlation between the tests of means and variances, and kurtosis invalidates the conventional F-test of equal variances.

The chi-square from comparing the means and variances of the circular-response and vertical-response answer sheets on NO was 242.757 (critical value = 5.991 at alpha = 0.05 and d.f. = 2). The corresponding chi-square for CS was 24.351. Table 10 (see *Supplement*, p. 10) shows the mean and variance for each type of answer sheet on each test; it also shows the t-ratio for the mean difference, the answer-sheet effect size, and the net answer sheet effect size (after subtracting the effect size for pre-existing differences between groups; see Table 9).

Power Tests. Answer-sheet effects were analyzed simultaneously for the set of power tests, for the reason indicated in the first paragraph of the previous section. The set of scores from power tests included in the analysis were GS, AR, AS, MK, MC, EI, and VE. The simultaneous test of equal means and variances consisted of using the same chi-square statistic as was employed for analyses of the speed tests; however, to maintain an expected number of Type I errors = 0.05 for the set of seven statistical tests, each chi-square was tested with an alpha level of 0.05/7 = 0.00714 (critical value = 9.883 with d.f. = 2).

Table 11 (see *Supplement*, p. S-11) shows the mean and variance for each of the seven power tests on each type of answer sheet. It also shows the chi-square for comparing the means and variances of the circular-response and vertical-response answer sheets; none of the chi-squares was statistically significant. Finally, to supplement the chi-square results, Table 11 shows the t-ratio for the mean difference, the answer-sheet-effect size for each test, and the net answer-sheet-effect size (after subtracting the effect size for pre-existing differences between groups; see Table 9). The non-significant t-ratios ($p > 0.05/7$), the effect-size estimates no larger than 0.030 (0.3 standard score points) in absolute value, and the net answer-sheet-effect sizes no larger than 0.02 in absolute value are consistent with the non-significant results provided by the chi-square test and do not indicate the presence of answer-sheet effects on the power tests.

Calibration of Tests With Answer-Sheet Effects

The presence of statistically significant answer-sheet effects for NO and CS indicated that the score scales for these tests on the circular-response answer sheet would need to be calibrated (i.e., transformed) to place their score levels on the same scales as the vertical-response answer sheet. The absence of answer-sheet effects for the other tests indicated that no new calibration of their score scales would be required.

Several methods of calibration were selected from alternatives reported in the literature on equating. Appendix F provides a discussion of the approaches which were considered and the reasons for selecting the methods used in these analyses:

- *Linear-rescaling equating*: the conventional linear procedure for converting number-right scores on the circular-response answer sheet to have the same mean and standard deviation as scores on the vertical-response answer sheet (e.g., see Angoff, 1971).

- *Linear-identity equating*: a linear equating based on assuming equal means and standard deviations of scores on the two answer sheets; this equating was obtained for reference only and was not considered for operational use because of the results of analyses of answer-sheet effects.

- *Raw equipercentile equating*: an equipercentile equating obtained from the unsmoothed frequency distribution for each answer sheet; this was obtained for reference only and was not considered for operational use because of its lack of smoothness and its large number of parameters.

- *Quartic log-linear equating*: an equipercentile equating obtained from the fourth-order, polynomial, log-linear smoothing of each distribution; the fourth-order polynomial was considered here because the first four terms of the polynomial were statistically significant for most ASVAB tests and forms in recruit distributions for the ASVAB 15/16/17 (see Appendix G).

- *Polynomial log-linear equating*: an equipercentile equating obtained from a log-linear smoothing that included all polynomial terms up through the highest-order statistically significant term (less than the eleventh term); this was based on a decision rule suggested by Haberman (see Holland & Thayer, 1987), with an upper bound placed on the number of terms in the polynomial.

- *Constrained second-order equating*: an equipercentile equating based on Segall's (1987, 1989) constrained second-order-difference smoothing of the frequency distributions.

Prior to each equipercentile equating, two modifications were made in the estimates of the cumulative distribution functions. First, the extreme lower tail of each distribution was smoothed in a way that would make the equating converge on an identity equating at the bottom of the number right score scale. The concern was that equipercentile equating is unstable where the score frequencies are small. The reason for making the equating converge on an identity equating instead of some other function was that equipercentile equating provides no alternative to assuming parallel measurement where the test contents are parallel and the score frequencies are small. The mechanism for making the equating converge on an identity equating here was to substitute a power function (see Appendix H) for the estimated cumulative distribution below the 0.5th percentile. The parameters of the function were chosen to preserve both the estimated frequency and cumulative distribution functions where the power function were attached. Such a procedure results in a relatively smooth equating function and does not affect the equating at scores above the 0.5th percentile. This mechanism is a modification of one used by Kolen and Brennan (1990); those authors used a linear function with a zero intercept instead of the more general power function, resulting in an equating that may not be very smooth at the 0.5th percentile if the test is short.

The second modification of the cumulative distributions prior to equipercentile equating was to shift the number-right score scale 0.5 to the right and to add a point ($X = -0.5$, $F(X) = 0.0$) at the lower end of the function. This was done so that the cumulative distribution would have the conventional interpretation as a continuous-score distribution that is uniform from 0.5 below each number-right score to 0.5 above each number-right score (Kolen & Brennan, 1990).

The final step in calibrating each test for the circular-response answer sheet was selecting one of the six equatings provided by the methods described above. This required comparing alternative equatings in the score metric (i.e., in terms of differences between their score scales) and in the frequency metric (i.e., in terms of differences between distributions of the equated scores). These comparisons were measured in terms of the algebraic difference between functions (root mean square difference) and in terms of the practical impact of those differences (i.e., percent of cases affected). Appendix I provides further details on these criteria and indices and lists heuristics which were used for selecting an equating.

Results of Linear and Equipercentile Calibrations: NO. Table 12 (see *Supplement*, p. S-12) lists the mean, variance, skewness, kurtosis, sample size, and frequency distribution for NO for each answer-sheet group in Phase I. These results and the 1980 Youth Population mean and standard deviation (in Table 1) were used to compute the unrounded standard-score equivalents for each equating method. (See Table 13 in the *Supplement*, p. S-13.)

Results of Linear and Equipercentile Calibrations: CS. Table 14 (see *Supplement*, p. S-14) lists the mean, variance, skewness, kurtosis, sample size, and frequency distribution for CS for each answer-sheet group. These results and the 1980 Youth Population mean and standard deviation (in Table 1) were used to compute the unrounded standard-score equivalents for each equating method.

(See Table 15 in the *Supplement*, p. S-15.)

Selecting an Equating for NO. Table 16 (see *Supplement*, p. S-17) summarizes the results used to compare the NO equatings in the score metric and in the frequency metric. The first part provides the root mean squared difference between each smooth equating and the raw equipercentile equating; the results indicated that the polynomial log-linear equating provided the best fit to the raw equipercentile equating. The second part of the table provides the root mean squared difference between the cumulative distribution of each set of smooth-equated scores and the cumulative distribution of the reference (vertical-response answer sheet) scores; the results show that none of the other equatings reduced the root-mean-square-discrepancy by at least 10% in the frequency metric without providing more than a 10% increase in the root-mean-square-discrepancy in the score metric. Thus, using heuristic (b) in Appendix I indicated that the polynomial log-linear equating provided the best fit to the data.

The third part of Table 16 shows the percentage of cases for which each pair of smooth equated score scales differed by more than 0.5 standard score points. The quartic log-linear equating had fewer parameters than the polynomial log-linear equating and differed from it by 0.5 points for fewer than 10% of the cases. The fourth part of the table provides, for each smooth equating, the percentage of cases for which the equated score distribution differed from the reference distribution (on the vertical-response answer sheet) by more than 0.01. Of the quartic log-linear and polynomial log-linear equating methods, only the latter provided a cumulative distribution differing from the reference distribution by more than 0.01 for fewer than 10% of the cases. Thus, using heuristic (d) in Appendix I resulted in the selection of the polynomial log-linear equating for the NO calibration; it had the fewest parameters without substantially reducing the fit to the data.

Several graphs of the results were inspected to provide a check on the proximity of the polynomial log-linear equating to the data from which it was developed:

- Figure 4 (see *Supplement*, p. S-68) shows the raw and polynomial-log-linear-smoothed frequency distributions for NO on the circular-response answer sheet.

- Figure 5 (see *Supplement*, p. S-69) shows these distributions for NO on the vertical-response answer sheet.

- Figure 6 (see *Supplement*, p. S-70) shows the raw and polynomial log-linear equipercentile equatings of NO number-right scores on the circular-response answer sheet to the standard score scale on the vertical-response answer sheet.

- Figure 7 (see *Supplement*, p. S-71) shows the contrast of each of these equatings and the linear rescaling equating with an identity equating, depicting where each equating had the greatest effect, as well as which method best approximated the raw equipercentile equating; also shown here is the circular-response-answer-sheet distribution that was used to weight these discrepancies in heuristic (a) in Appendix G.

- Figure 8 (see *Supplement*, p. S-72) shows the contrast of the reference cumulative distribution with the distribution from each of three equatings: linear rescaling, linear identity, and polynomial log-linear equipercentile; also shown here is the vertical-response-answer-sheet distribution that was used to weight these contrasts in heuristic (b) given in Appendix I.

An inspection of the results in Figures 7 and 8 did not reveal a substantial discrepancy between the polynomial log-linear equating and the data from which it was developed.

Selecting an Equating for CS. Table 17 (see *Supplement*, p. S-18) summarizes the results used to compare the CS equatings in the score metric and in the frequency metric. The first part provides the root mean squared difference between each smooth equating and the raw equipercentile equating; the results indicated that the polynomial log-linear equating provided the best fit to the raw equipercentile equating. The second part of the table provides the root mean squared difference between the cumulative distribution of each set of smooth-equated scores and the cumulative distribution of the reference (vertical-response answer sheet) scores; the results show that none of the other equatings provided at least a 10% reduction in the root-mean-square-discrepancy in the frequency metric without providing more than a 10% increase in the root-mean-square-discrepancy in the score metric. Thus, using heuristic (b) in Appendix I indicated that the polynomial log-linear equating provided the best fit to the data.

The third part of Table 17 provides the percentage of cases for which each pair of smooth equated score scales differed by more than 0.5 standard score points. The linear rescaling and quartic log-linear equatings each had fewer parameters than the polynomial log-linear equating and differed from the latter by 0.5 points for fewer than 10% of the cases. The fourth part of the table provides, for each smooth equating, the percentage of cases for which the equated score distribution differed from the reference distribution (on the vertical-response answer sheet) by more than 0.01. Of the linear rescaling, quartic log-linear, and polynomial log-linear equating methods, only the polynomial log-linear equating provided a cumulative distribution differing from the reference distribution by more than 0.01 for fewer than 10% of the cases. Thus, using heuristic (d) in Appendix I resulted in the selection of the polynomial log-linear equating for the CS calibration; it had the fewest parameters without substantially reducing the fit to the data.

Several graphs of the results were inspected to provide a check on the proximity of the polynomial log-linear equating to the data from which it was developed:

- Figure 9 (see *Supplement*, p. S-73) shows the raw and polynomial-log-linear-smoothed frequency distributions for CS on the circular-response answer sheet.

- Figure 10 (see *Supplement*, p. S-74) shows these distributions for CS on the vertical-response answer sheet.

- Figure 11 (see *Supplement*, p. S-75) shows the raw and polynomial log-linear equipercentile equatings of CS number-right scores on the circular-response answer sheet to the standard score scale on the vertical-response answer sheet.

- Figure 12 (see *Supplement*, p. S-76) shows the contrast of each of these equatings and the linear rescaling equating with an identity equating; also shown here is the circular-response-answer-sheet distribution that was used to weight these contrasts in heuristic (a) given in Appendix I.

- Figure 13 (see *Supplement*, p. S-77) shows the contrast of the reference cumulative distribution with the distribution from each of three equatings: linear rescaling, linear identity, and polynomial log-linear equipercentile; also shown here is the vertical-response-answer-sheet distribution that was used to weight these contrasts in heuristic (b) given in Appendix I.

An inspection of the results in Figures 12 and 13 does not reveal a substantial discrepancy between the polynomial log-linear equating and the data from which it was developed.

Development of Conversion Tables

The ASVAB 8f/13h/15h/18h Reference Form. Before the circular-response answer sheets could be used operationally, number-right scores on each test had to be converted to standard score equivalents in the metric of the 1980 Youth Population. For those tests that showed no answer-sheet effect (the power tests), the conversion tables could be the same as the tables previously used to convert number-right scores from the vertical-response answer sheet (U.S. Department of Defense, 1989). However, the speed tests that showed answer-sheet effects (NO and CS) required circular-response conversion tables.

The standard score equivalents in Tables 13 and 15 provide the information required for the answer-sheet conversion tables for NO and CS, respectively, on the ASVAB 8a and equivalent forms. For the selected equipercentile equatings (polynomial log-linear on NO and CS), the standard score equivalents were rounded to the nearest integer and truncated at 20. The rounding followed the convention of rounding up if the decimal remainder is greater than or equal to 0.5 and rounding down otherwise. The truncation followed the ASVAB convention of limiting the standard score scale to values between and including 20 and 80 (Maier & Sims, 1986). The resulting conversion table for use of the circular-response answer sheet with the ASVAB 15c (equivalent to the ASVAB 8a) in the IOT&E, and with 18c in the Student Testing Program is given in Table 18 (see *Supplement*, p. S-19); the tabled values for NO and CS are from this study; the values for the other tests are the same as in the ASVAB 8a conversion table (U.S. Department of Defense, 1989) that is used with the vertical-response answer sheet.

To avoid confusion with the conversion tables used for the ASVAB 8a/13c/15c/18c with the vertical-response answer sheet, Table 18 is labeled for use with the ASVAB 8f/13h/15h/18h, even though the test booklets contain the same items as the ASVAB 8a/13c/15c/18c. Table 19 (see *Supplement*, p. S-21) shows the correspondence of all current ASVAB booklets and their form designations to be used with the vertical-response and circular-response answer sheets (Defense Manpower Data Center, 1990).

The ASVAB 14f/14g/14h Discontinued Forms. The Student Testing Program had been using test standard scores from the ASVAB 14a/14b/14c in various combinations for career exploration. Also, in some cases, the Military Services were using composites of the scores in determining eligibility for military selection and classification. USMEPCOM planned to begin use of the circular-response answer sheets in the Student Testing Program after the IOT&E of circular-response answer sheets in the Enlistment Testing Program. It was assumed that the calibration of the circular-response answer sheets for the Enlistment Testing Program would also be valid for the Student Testing Program unless evidence from Phase II of this study showed that assumption to be questionable. Therefore, answer-sheet conversion tables were required for the ASVAB 14 forms.

One conversion table was used for all three ASVAB 14 forms with the vertical-response answer sheet, the same table as the one used for the ASVAB 8a. Therefore, the table used for the ASVAB 14 with the circular-response answer sheet was the same as the one shown in Table 18 for the ASVAB 8a and equivalent forms; as indicated in Table 19, this is labeled for use with the ASVAB 14f/14g/14h (Defense Manpower Data Center, 1990).

The ASVAB 15f/g to 19f/g Operational Forms. The Enlistment Testing Program has been using the ASVAB 15a/15b/16a/16b/17a/17b, and the Student Testing Program currently uses the ASVAB 18a/18b/19a/19b. With the vertical-response answer sheet, number-right scores were converted to standard-score equivalents by using conversion tables based on a previous equating of these ten forms to the ASVAB 15c/18c. Because the power tests showed no answer-sheet effect in the study, the previously used conversion tables can be employed with both the circular-response answer sheet, as well as with the vertical-response answer sheet. However, because the speed tests showed an answer-sheet effect (NO and CS), new conversion tables are needed for use with the circular-response answer sheet. These tables cannot be the same as given in Table 18 because the ASVAB 15/16/17/18/19 do not have an identity equating with the ASVAB 15c/18c.

Four steps were used in the development of conversion tables for the ASVAB 15/16/17/18/19:

- First, the equatings selected for NO and CS in this study were used to convert integer number-right scores on the circular-response answer sheet to fractional number-right-equivalent scores on the vertical-response answer sheet. These were assumed to be valid for calibrating the circular-response answer sheet for all ten operational forms, an assumption to be tested later in an IOT&E of the circular-response answer sheets.

- Second, the linear equatings currently used with the ASVAB 15/16/17, or in the IOT&E of the ASVAB 18/19, were employed to convert the fractional number-right score to the equivalent fractional number-right on the ASVAB 15c/18c.

- Third, the 1980 Youth Population means and standard deviations (Table 1) were used to convert the ASVAB 15c/18c-equivalent fractional number-right score to the standard score metric.

- The fourth step in developing conversion tables for the ASVAB 15/16/17/18/19 was rounding the standard score equivalents and truncating them at 20. The resulting integers provided the values for NO and CS, respectively.

Answer-sheet fractional number-right equivalents and equated standard score equivalents for NO are provided in Table 20 (see *Supplement*, p. S-22) for the ASVAB 15/16/17 and in Table 21 (see *Supplement*, p. S-23) for the ASVAB 18/19. These equivalents for CS are provided in Table 22 (see *Supplement*, p. S-24) for the ASVAB 15/16/17 and in Table 23 (see *Supplement*, p. S-25) for the ASVAB 18/19. (Note that, in some cases, standard score conversions are provided for combinations of the ASVAB forms instead of for only single forms; this has been done where forms with duplicate items and very similar score distributions were combined for equating purposes.)

Table 24 (see *Supplement*, p. S-26) shows the means, standard deviations and linear equatings of NO and CS from the ASVAB 15/16/17 IOT&E data set, and the ASVAB 18/19 OPCAL data set provided to DMDC by the Air Force Human Resources Laboratory.

Tables 25-34 (see *Supplement*, pp. S-27 through S-46) contain rounded standard scores for use with the ASVAB test booklets 15a/15b/16a/16b/17a/17b/18a/18b/19a/19b under administration with the circular-response answer sheets. As indicated in Table 19, the conversion tables are designated for use with the ASVAB 15f/15g/16f/16g/17f/17g/18f/18g/19f/19g, respectively, to avoid confusion with tables to be used with the vertical-response answer sheets.

Distributions of Composites of Converted Test Scores

The ASVAB test standard scores are used in various combinations to determine qualification for military enlistment and for classification into occupational specialties. Table 35 (see *Supplement*, p. S-47) shows the test combinations for the AFQT and for the Services' occupational specialty composites (U.S. Department of Defense, 1989). In practice, the AFQT and Air Force composites of test standard scores are transformed to a percentile score, the Army and Marine Corps composites are transformed to standard scores with a mean of 100 and a standard deviation of 20, and the Navy composites are used without a further transformation of the score scale. Minimum cut scores on the composites are then used to place applicants and recruits into categories to determine eligibility for selection and classification.

In an earlier section of this report, the impact of using the equated circular-response answer sheet was described in comparisons of distributions of equated test scores with distributions of scores on the vertical-response answer sheet. To further evaluate the impact of using the equated circular-response answer sheets, the conversions in Table 18 were applied to all test scores from the circular-response answer sheet in the present study; also, the vertical-response conversion table for the ASVAB 8a (U.S. Department of Defense, 1989) was applied to all test scores from the vertical-response answer sheet in the present study. Then, the resulting scores were used to compute the composites listed in Table 35. Finally, the distributions of the composites and the cut scores shown in Table 36 (see *Supplement*, p. S-48) were used to assess the number of subjects in each category for each answer-sheet condition. For some composites, adjacent categories in Table 36 were combined so that sample sizes would be adequate for statistical analyses of category-by-answer-sheet frequency tables.

The number of cases in each composite category for each type of answer sheet was analyzed in a m x 2 Pearson chi-square, where m was the number of categories for the composite. The resulting chi-squares and degrees of freedom are shown in Table 37 (see *Supplement*, p. S-49). Four of the nine composites using NO or CS (tests for which conversion tables differed across answer sheets) had chi-squares greater than their degrees of freedom. The smallest probability for these nine chi-squares (0.074 for the Navy BC composite) approached, but did not reach, statistical significance at the 0.05 level. With the possible exception of the result for the Navy BC composite, these results suggested that the circular-response answer sheet conversion tables for NO and CS effectively removed the differences between the answer sheets for these tests in the sample used in this study. The result for the Navy BC composite may have been due to a combination of two factors: (a) its inclusion of VE, on which the vertical-response-answer-sheet group performed slightly better than the circular-response-answer-sheet group (Table 9), and (b) the use of high cut scores on BC (Table 36); as explained below, tendencies towards random non-equivalence of the two groups appeared to be more prevalent in the high range of the score scales.

An additional analysis was conducted to investigate the AFQT boundaries at which the two answer-sheet groups differed because (a) the chi-square for the AFQT composite approached statistical significance, and (b) the chi-squares for the Army GT and Navy ME composites reached statistical significance (Table 37). Also, because of the importance of this analysis, an alpha level of 0.05 was used for testing the null hypothesis for each composite. (In interpreting these results, it should be noted that this procedure had a smaller conceptual unit of the error rate than was used in earlier analyses of answer-sheet effects on the power tests. Therefore, differences here were more likely to be statistically significant than was true in the preceding analyses of answer-sheet differences.)

For each answer-sheet group, Table 38 (see *Supplement*, p. S-50) shows the percentage of

persons with AFQT scores at or above the indicated category levels; the table also shows the difference between the percentages and the two-standard-error confidence bounds of the difference at each category level. The results show significantly more persons on the vertical-response answer sheet had AFQTs above 64 (AFQT Categories I and II); at no other AFQT category boundary was the difference between the two groups statistically significant. The direction of the difference (higher scores on the vertical-response answer sheet) was consistent with the direction of the non-significant differences for all of the AFQT tests in Table 11. The direction of the difference was also consistent with expectations from the slightly higher pre-enlistment AFQT test means for the vertical-response-answer-sheet group (Table 9). When considered in conjunction with the small, net effect sizes for the AFQT tests in Table 11, these results suggest that the significant differences shown in Table 38 were due to random non-equivalence of groups on the AFQT tests.

PHASE II

Data Quality Control and Editing

Phase II used the same procedure as was used in Phase I to identify and exclude from the analyses, all data from those subjects with a substantial number of test scores below what would be expected from purely random responding. Table 39 (see *Supplement*, p. S-51) shows, for each test and for each type of answer sheet, the expected number correct from random responding and the percentage of subjects scoring at or below this level. Table 40 (see *Supplement*, p. S-52) shows, for each type of answer sheet, the distribution of the number of tests on which subjects score at or below this level.

Based on the information in Table 40, it was decided to remove data obtained from subjects who scored at or below the chance level on three or more tests. This criterion was the same as was used in Phase I and was judged to provide a balance between the necessity of removing data of aberrantly low-scoring subjects and the necessity of retaining the number data points required for developing adjustments of conversion tables. It resulted in the loss of data from $3/360 = 0.008$ of the subjects in the enlistment-answer-sheet group and $1/352 = 0.003$ of the subjects in the student-answer-sheet group.

Equivalence of Groups

For the data collection in Phase II, the two types of answer sheets (circular-response *student* answer sheets and circular-response *enlistment* answer sheets) were distributed in alternation to subjects in each testing session. As in Phase I, analyses were conducted to assess the equivalence of the two groups with respect to background characteristics and performance on the ASVAB taken prior to enlistment. If the two groups differed on characteristics in addition to the answer sheet used to administer the ASVAB, differences in performance could be attributed to those characteristics as well as to the answer sheet. As a check on the possibility of such a confound, the two groups were compared with respect to background characteristics (i.e., gender and ethnicity) and performance on an earlier ASVAB (i.e., an ASVAB taken prior to enlistment).

Table 41 (see *Supplement*, p. S-53) provides frequencies and percentages at each level of the background variables for each of the two answer-sheet groups. Table 42 (see *Supplement*, p. S-54) provides test means and standard deviations of each group, plus the t-ratios and effect-sizes based on

these means; the two verbal tests are not included here because they are not used for enlistment processing other than through their raw score sum, VE. The results showed no statistically significant difference (alpha = 0.05) between the two answer-sheet groups. This suggested that the two answer sheets in Phase II were sufficiently equivalent to proceed with analyses of answer-sheet effects.

Answer-Sheet Effects

Answer-sheet effects were analyzed simultaneously for the set of all tests because there was no apriori basis for predicting differences between the circular-response answer sheets for the student and enlistment ASVABs. The set of tests included in the analysis was the same as was used in Phase I. The simultaneous test of equal means and variances consisted of using the same chi-square statistic as was employed for analyses of answer-sheet effects in Phase I; to maintain an expected number of Type I errors = 0.05 for the set of nine statistical tests, each chi-square was tested with an alpha level of 0.05/9 = 0.00556 (critical value = 10.386).

Table 43 (see *Supplement*, p. S-55) shows the mean and variance for each of the nine tests on each type of answer sheet. It also shows the chi-square for comparing the means and variances of the circular-response and vertical-response answer sheets; none of the chi-squares was statistically significant. Finally, Table 43 shows the t-ratio for the mean difference, the answer-sheet effect size for each test, and the net answer-sheet effect size (after subtracting the effect size for pre-existing differences between groups; see Table 34b). The non-significant t-ratios ($p > 0.05/9$) and the net effect size estimates no larger than 0.089 in absolute value were consistent with the results provided by the chi-square test and did not indicate the presence of differences between the student and enlistment answer sheets.

DISCUSSION

The results of this study indicate that use of the circular-response answer sheet with speed tests of the ASVAB produces lower scores than does use of the vertical-response answer sheet; the results further indicate no difference between use of the two answer sheets with the power tests. The direction and magnitude of the effects on speed tests was consistent with the direction and magnitude of the differences found earlier by Ree and Wegner (1990) between the circular-response answer sheet used in norming the ASVAB and the vertical-response answer sheet used for operational testing at the time of the present study.

The results of this study also included conversion tables to be used when the circular-response answer sheet is used along with the ASVAB 15/16/17 in the Enlistment Testing Program and the ASVAB 14 and 18/19 in the Student Testing Program. The tables were developed for operational use in an Initial Operational Test and Evaluation (IOT&E) of the circular-response answer sheets and, if necessary, after the IOT&E until analyses of the IOT&E data provide alternative tables. Although the tables were based on careful analyses of available data, it was expected that they would be replaced by conversion tables based on data from the IOT&E. This is because these tables were based on an equipercentile equating, an equating which is defined for the population in which it is developed and is not necessarily accurate in other populations (Lord & Wingersky, 1983; Braun & Holland, 1982;

Monzon, Shamieh, & Segall, 1990). In this study, the tables were developed using samples from a population of military recruits and were to be utilized in a (less selected) population of military applicants and students.

Even if the conversion tables provided by this study are correct for short-term use in an applicant population, they can become incorrect over time if an increasing number of examinees are coached on effective strategies for responding on the circular-response answer sheet. The vertical-response answer sheet was subject to score inflation on speed tests if military applicants filled response spaces more lightly and quickly than was done by examinees when the tests were normed. After the implementation of the circular-response answer sheet, it may be discovered that examinees need not completely fill in the circular-response spaces or keep pencil marks strictly within the spaces in order to obtain credit for correct answers. If this occured during the IOT&E, the conversion tables developed here could be valid for only the early stage of data collection. A more insidious implication of this is that IOT&E-based conversion tables may not be valid a few months after the IOT&E, necessitating a subsequent Operational Test and Evaluation to make further adjustments in the calibration. This points to the need for plans to (a) experimentally test the effect of response strategies on the circular-response answer sheet, and (b) conduct intermittent checks of the score scale during the first year of operational use of the circular-response answer sheets.

SUMMARY AND CONCLUSIONS

In 1992, the United States Military Entrance Processing Command (USMEPCOM) purchased and installed new optical mark readers to scan answer sheets for the Armed Services Vocational Aptitude Battery (ASVAB). This necessitated using new answer sheets which differed from the vertical-response answer sheets that were in use at the time. The results of this study indicate that the use of the new, circular-response answer sheets with the speed tests of the ASVAB produces lower scores than are produced with the use of the vertical-response answer sheet. The direction and magnitude of this effect was consistent with the direction and magnitude of the difference found earlier by Ree and Wegner (1990) between the vertical-response answer sheets and the circular-response answer sheets which were used to norm the ASVAB.

This study utilized data obtained from military recruits to develop conversion tables for an Initial Operational Test and Evaluation (IOT&E) of the circular-response answer sheets with the ASVAB 15/16/17. The results also included conversion tables to be used with circular-response answer sheets and the ASVAB 14 and 18/19 in the Student Testing Program. It was assumed that adjustments would be made in all of these conversion tables subsequent to analyses of data from the IOT&E of the circular-response answer sheets; unlike the analyses used to develop the tables presented here, analyses of the IOT&E data would be based on samples which are representative of the full distribution of applicants for Military Service.

APPENDIXES

Appendix A

Quality Control Procedures for Test Administration

TEST ADMINISTRATOR RECORD KEEPING FORM

Test Date & Time	Number of Recruits		Test Administrator Interruptions
	Current (Rectangular)	New (Circular)	
Page Totals			

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WEEKLY ANSWER FORM PROCESSING SHEET

Date Mailed _____ Ft. Jackson, SC

RTC Site No. 0001

Period of Testing _____

Number of Answer Forms in this Mailing:

Rectangular spaces on current answer sheet
OOD 1304.12PTANSWRSHT JAN90 = _____

Circular spaces on new answer sheet
OMR PRODUCTION JAN 90 = _____

Test Administrator Name(s) _____

_____

****

Appendix B:

Privacy Act Statement

AUTHORITY: 44USC 3103, 10USC 3012, E09397

Principal Purpose: This information will be used solely for research purposes. Use of the social security account number is necessary to make positive identification of the individual and records.

Routine Use: Information provided by respondents will be treated as CONFIDENTIAL and will be used for official purposes only. Individual identity will not be revealed.

Disclosure: Disclosure is mandatory. Failure to provide information would hinder DoD's ability to improve the effectiveness of the personnel system.

I certify that I am physically and mentally fit to take this test.

_____

SIGNATURE

Appendix C

Phase II Test Administration Directions

Beginning with actual instructions for providing identifying information on answer sheets in Phase II:

3. Completing the Identification Information on the Answer Forms

Now say:

There are two different answer forms. One is orange and the other is pink. With the perforations on the right, the orange form says OMR PRODUCTION JAN 90 at the bottom. We will refer to this answer form as the orange or PRODUCTION form. The pink form says OMR STUDENT JAN 90 at the bottom. We will refer to this answer form as the pink or STUDENT form. Pay close attention to the directions, as there are differences in the two forms.

Now say:

If you have the orange or PRODUCTION answer form, you should have four pages fastened together. Do not separate them. The first page has parts 1 through 5 on it. The second page has parts 6 and 7 on it. The third page has parts 8 through 10 on it. The fourth page has parts 1, 2, and 3 of the Adaptability Screening Profile (ASP). You will not take this test after the ASVAB today. If you have the orange or PRODUCTION form, make sure that you have these four pages. If you do not, hold up your hand.

Pause, then say:

If you have the pink or STUDENT answer form, you should have three pages, fastened together. Do not separate them. The first page has name, address, and other identifying information. The second page has parts 1 through 5 on it. The third page has parts 6 through 10 on it. If you have the pink or STUDENT answer form, make sure that you have these three pages. If you do not, hold up your hand.

Pause, then say:

Make sure that the page number of your answer form is in the upper right corner. In the upper center portion of the answer form, there is a black printed serial number. Find the serial number. That same number should also be printed in the upper center portion of pages 2 and 3. Check now to make sure that the serial number is identical on the first three pages of your answer form. If there is a difference, please raise your hand.

Pause, make necessary corrections, then say:

Due to the differences in the answer forms, I will give you instructions for one form at a time. If you have the pink of STUDENT form, do not write anything on your answer form until told to do so.

Pause, then say:

If you have the orange or PRODUCTION answer form, turn your answer form sideways so that you can read the sections for name, test version, etc. In the upper left-hand corner on the line provided, put your Social Security Number.

Pause, then say:

On the orange or PRODUCTION answer form, to the right of your Social Security Number, print your last name, first name, then your middle initial on the line provided.

Pause. Check to see that instructions are properly followed, then say:

On the orange or PRODUCTION answer form, to the right of your middle initial, above the heading of "LAST NAME", print your last name or the first eight (8) letters of your last name if it is longer. Print the first letter in the first box, second letter in the second box, and so on. Then blacken the corresponding spaces below the letters you have printed.

Proctors check to see that instructions are properly followed. Allow time for applicants to finish, then say:

For those with the orange or PRODUCTION answer form, look at your test booklet. On the front cover of your test booklet, under the test name, you should find form number 13c. Find the form number now. If you have a different form number on your test booklet, please raise your hand.

Pause, make necessary corrections, then say:

On the orange or PRODUCTION answer form, in the upper right-hand corner, immediately to the right of your last name, find the block labeled "ASVAB TEST VERSION." Write 13c in the blocks and blacken the corresponding spaces below.

Pause.

On the orange or PRODUCTION answer form, under the heading of "SEX", blacken the appropriate space.

Pause, write date on board in proper format (for example 90-04-02).

On the orange or PRODUCTION answer form, under the heading of "ASVAB DATE", blacken the spaces for today's date. Today's date is (*year, month, day*).

Pause. Proctors must insure that the date is entered correctly as called for on the answer form, then say:

On the orange or PRODUCTION answer form, in the lower right corner above the heading of "SOCIAL SECURITY NO.", write your Social Security Number in the boxes and blacken the appropriate spaces.

Pause, then say:

If you have the orange or PRODUCTION answer form, you have completed the identifying information on page 1. Do not write anything else until told to do so.

Pause, then say:

If you have the pink or STUDENT answer form, you will now follow instructions for completing page 1. Do not work ahead of the instructions because you will not be completing all of the information blocks.

Pause, then say:

On the pink or STUDENT answer form, print your last name, first name, then your middle initial in the spaces provided. Print the first letter in the first box, second letter in the second box, and so on. Then blacken the corresponding spaces below the letters you have printed.

Pause, write your test site number (written in spaces below) on board, then say:

On the pink or STUDENT answer form, skip the blocks numbered 2 through 6 which will not be used today. In block number 7 find the heading of "SCHOOL NUMBER". Above the heading of "SCHOOL NUMBER," enter the site number (_ _ _) and blacken the corresponding numbers in each column below. Skip blocks 8 and 9 which will not be used today.

Pause, then say:

On the pink or STUDENT answer form, in block number 10 under the heading of "POPULATION GROUP," blacken the appropriate space to show the population group of which you consider yourself to be a member.

Pause, then say:

In block 11 under the heading of "SEX," blacken the appropriate space. Skip block 12 "INTENTIONS" which will not be used today.

Pause, then say:

For those with the pink or STUDENT answer form, look at your test booklet. On the front cover of your test booklet, under the test name, you should find form number 13c. Find the form number now. If you have a different form number on your test booklet, please raise your hand.

Pause, make necessary corrections, then say:

On the pink or STUDENT answer form, find block 13 "TEST VERSION." Write 13c in the blocks and blacken the corresponding spaces below.

Pause, then say:

For those with the pink or STUDENT answer form, skip block number 14 "TEST BOOKLET NUMBER" which will not be used today. This completes the information on page 1. Do not write anything else on your answer form until told to do so.

Pause, then say:

For those with the orange or PRODUCTION answer form, turn to the second page keeping it horizontal. At the top, print your Social Security Number and your last name, first name, and middle initial.

Pause, then say:

On the orange or PRODUCTION answer form, in the lower right corner, above the heading of "SOCIAL SECURITY NO.", write your Social Security Number in the boxes and blacken the appropriate spaces.

Pause, then say:

On the orange or PRODUCTION answer form, find the block labeled "TEST SITE." Above the heading of "TEST SITE" enter the test site number (_ _ _ _) and blacken the corresponding numbers in each column below.

Pause, then say:

If you have the orange or PRODUCTION answer form, this completes the information on page 2. Do not write anything else on your answer form until told to do so.

Pause, then say:

For those with the pink or STUDENT answer form, turn to the second page keeping it horizontal. At the top, print your Social Security Number and your last name, first name, and middle initial.

Pause, then say:

If you have the pink or STUDENT answer form, in block 15 above the heading of "SOCIAL SECURITY NO.," write your Social Security Number in the boxes and blacken the appropriate spaces. Skip blocks 16 and 17 which will not be used today.

Pause, then say:

If you have the pink or STUDENT answer form, find block 18 labeled "SP STUDIES." Above the heading of "SP STUDIES" enter the number "0 0 0 3" and blacken the corresponding numbers in each column below.

Pause, then say:

If you have the pink or STUDENT answer form, this completes the information on page 2. Do not write anything else on your answer form until told to do so.

Pause, then say:

For those with the orange or PRODUCTION answer form, turn to the third page and again

print your Social Security Number and your name at the top of the page.

Pause, then say:

On the left side of the orange or PRODUCTION answer form under the heading of "POPULATION GROUP", blacken the appropriate space to show the population group of which you consider yourself to be a member.

Pause, then say:

If you have the orange or PRODUCTION answer form, find the block labeled "SP STUDIES". Above the heading of "SP STUDIES," enter the number "0 0 0 2" and blacken the corresponding numbers in the columns below.

Pause, then say:

On the orange or PRODUCTION answer form in the lower right corner above the heading of "SOCIAL SECURITY NO.", write your Social Security Number in the boxes and blacken the appropriate spaces. This completes the identifying information for the orange or PRODUCTION answer form.

Pause, then say:

For those with the pink or STUDENT answer form, turn to the third page and again print your Social Security Number and your name at the top of the page.

Pause. Make sure instructions are followed, then say:

This completes the identifying information for both answer forms. Now everyone should turn the answer form right side up and return to the first page so the words "Answer Sheet, Armed Services Vocational Aptitude Battery, Page 1" now appear in the upper right-hand corner.

Pause, then say:

Now open your test booklet to page 1 and read the general directions silently while I read them aloud.

Appendix D

A Chi-square Statistic for a Two-sample Comparison of Means and Variances

Let the	notation for	Sample 1	and Sample 2
be	mean	M1	M2,
	standard deviation	S1	S2,
	skewness	W1	W2,
	kurtosis (minus 3)	K1	K2,
and	sample size	N1	N2.

Compute variances of means, $A1 = (S1)^{**}2 / .$
and $A2 = (S2)^{**}2 / N2,$
where **i denotes "taken to the power i."

Compute variances of variances, $B1 = (2 + K1)\,(S1)^{**}4 / N1$
and $B2 = (2 + K2)\,(S2)^{**}4 / N2.$

Compute covariances of means and variances, $C1 = (W1)\,(S1)^{**}3 / N1$
and $C2 = (W2)\,(S2)^{**}3 / N2.$

Compute pooled variances and covariances, $A = A1 + A2$
$B = B1 + B2,$
and $C = C1 + C2.$

Compute differences of means and variances, $DM = M1 - M2$
and $DV = (S1)^{**}2 - (S2)^{**}2.$

Invert a 2x2 matrix of pooled variances and covariances,

$AI = B / DEN$ (first diagonal element),
$BI = A / DEN$ (second diagonal element),
and $CI = -C / DEN$ (off-diagonal element),
where $DEN = (A)(B) - (C)^{**}2.$

Compute the asymptotic chi-square with 2 degrees of freedom,

$$CHI\text{-}SQUARE = (DM)\,(Z1) + (DV)\,(Z2),$$

where $Z1 = (DM)\,(AI) + (DV)\,(CI)$
and $Z2 = (DM)\,(CI) + (DV)\,(BI).$

Appendix E

Skewness and Kurtosis of Tests in the Operational Calibration* of the ASVAB 15/16/17

Test	Index	15a	15b	15c	16a	16b	17a	17b	median
GS	Skewness	-.19	-.18	-.20	-.26	-.27	-.35	-.35	-.26
	Kurtosis	-.59	-.57	-.39	-.56	-.54	-.33	-.26	-.54
AR	Skewness	.00	-.08	.02	-.08	-.06	-.04	-.14	-.06
	Kurtosis	-.85	-.83	-.78	-.53	-.77	-.81	-.68	-.68
WK	Skewness	-.85	-.80	-.74	-.73	-.76	-.66	-.86	-.76
	Kurtosis	.36	.51	.44	.38	.53	.11	.65	.44
PC	Skewness	-1.28	-1.26	-.97	-1.28	-1.16	-1.12	-1.16	-1.16
	Kurtosis	1.68	1.71	.91	1.67	1.39	1.18	1.54	1.54
NO	Skewness	-.89	-.90	-.96	-1.11	-.85	-.92	-.92	-.92
	Kurtosis	.29	.21	.37	.96	-.01	.25	.27	.27
CS	Skewness	.02	.03	-.06	.04	-.08	.05	.05	.05
	Kurtosis	-.10	-.07	.00	-.09	-.11	-.07	-.08	-.08
AS	Skewness	-.05	-.05	-.09	-.10	-.22	-.12	-.06	-.09
	Kurtosis	-.95	-.92	-.81	-1.05	-.96	-.94	-.89	-.94
MK	Skewness	-.02	-.03	.11	.05	.03	.09	.05	.05
	Kurtosis	-.89	-.88	-.86	-.90	-.96	-.86	-.79	-.88
MC	Skewness	-.22	-.23	-.15	-.23	-.32	-.19	-.26	-.23
	Kurtosis	-.65	-.71	-.75	-.68	-.61	-.56	-.40	-.65
EI	Skewness	-.07	.08	-.21	-.08	-.12	-.08	-.07	-.08
	Kurtosis	-.48	-.62	-.51	-.52	-.58	-.70	-.67	-.58
VE	Skewness	-.90	-.87	-.78	-.83	-.77	-.71	-.82	-.82
	Kurtosis	.56	.76	.51	.58	.44	.19	.61	.56
N		2774	2756	2504	2678	2712	2501	2540	

* Joint-Service Samples from Recruit Training Centers

Appendix F

Alternative Methods of Calibration

Several approaches can be considered for calibrating tests on the circular-response answer sheets so that their scores will be on the same score scale as on the vertical-response answer sheet. The primary approaches considered here are the following methods of equating: random-groups linear equating, random-groups equipercentile equating, matched-groups linear equating, and matched-groups equipercentile equating. True-score equating is not considered here because of the lack of research and experience related to equating from an item response theory for speed tests. Summary descriptions of these five approaches are provided in Angoff (1971); Braun and Holland (1982); Peterson, Kolen, and Hoover (1989); Kolen and Brennan (1990); and Dorans (1990a).

Even though a randomly-equivalent-groups design is typically used for ASVAB equating data collection, matched-groups equating methods can be considered when the subjects are military recruits. These methods offer the potential for controlling for whatever random differences occur between groups. The matching variable in this case would be the pre-enlistment ASVAB score on the test being calibrated. Any association of this score with the score on the test being calibrated could potentially be exploited to improve the precision of the calibration.

In spite of this theoretical advantage of matched-groups equating, the approach is not considered further here. The main concern is that the approach has not been demonstrated to improve the precision of the calibration in the present context. What is distinctive about this context is that the matching variable (pre-enlistment ASVAB) is a measure taken, in some cases, two years prior to the test being calibrated and under different motivational conditions. This is in contrast to conventional matched-groups equating in which the matching variable is a measure taken in close temporal proximity to, and under similar motivational conditions as, the test being calibrated. Systematic influences between the measurement of the matching variable and the test being calibrated include substantial selection (50% for military enlistment), learning (during the final year of secondary education), and motivational changes (from operational to non-operational conditions of administration). This, plus the highly skewed--in the case of NO, monotonic--distributions of the ASVAB tests, make it difficult to assume that the results of previous studies of matched-groups equating (e.g., see Dorans [Ed.], 1990b) generalize to the present context. However, there is a need for ASVAB studies of matched-groups equating (e.g., using the evaluation design employed by Divgi, 1988) so that any improvements obtainable by this approach could be exploited in future calibrations.

Random-groups linear equating and random-groups equipercentile equating are considered here because of prior experience in the use of these approaches for the ASVAB equating and answer-sheet calibration. Both approaches were used in the answer-sheet calibration study by Ree and Wegner (1990). Also, Divgi (1988) compared linear and equipercentile equatings from recruit samples and, for each approach, found tests in which the approach provided the best prediction of equating in large samples of military applicants.

Three criteria guide the choice among alternative smoothing methods for use in equipercentile equating:

- The first criterion is that the method be symmetric so that the calibration can serve as a basis for converting scores on either answer sheet to the score scale provided by the other answer sheet; this is a criterion that has been advocated by Lord (1980); Peterson, Kolen, and Hoover (1989); and Dorans (1990a) in support of the idea of interchangability of equated test forms.

- The second criterion is that the method of estimating score distributions use a statistical measure of fit to the distributions of scores on the two answer sheets.

- The third criterion is that there be a sequence of distributional models, differing primarily in their number of parameters; the objective here is to choose the model with the smallest number of parameters to reduce sampling variability in the distribution estimator.

Two methods of equipercentile equating satisfy these three criteria. Each method results in symmetric equating by using a flexible functional form to independently smooth the distribution of scores obtained from each answer sheet. Then, the smoothed distributions are used to obtain an equipercentile equating of scores on the circular-response answer sheet to the score scale on the vertical-response answer sheet. This approach has been termed pre-smoothing (Fairbank, 1987).

Each of the two methods also uses a statistical measure of fit to the distributions when the parameters are being estimated. The first smoothing method, that of log-linear smoothing, employs the method of maximum likelihood to fit polynomials to the logarithm of the frequency distributions, in a manner suggested by Holland and Thayer (1987). This method is implemented by a computer program (Hanson, 1990). The second method, that of constrained second-order-difference smoothing, constrains the log-likelihood chi-square to be equal to the maximum of the chi-square density (given the degrees of freedom) while minimizing second-order differences in the slope of a piece-wise linear distribution estimator (Segall, 1987 and 1989). This method is implemented by an algorithm and computer program also developed by Segall (1989).

Finally, the two equipercentile methods collectively provide a sequence of distributional models differing primarily in their numbers of parameters. The log-linear method uses as many terms in the polynomial as are necessary to provide a good fit to the non-null bins of the distribution. The constrained second-order-difference method uses one fewer terms than there are non-null bins of the distribution. Thus, the latter method is nearly certain to have more parameters than the polynomials considered under the log-linear method. It should be noted, however, that the constrained second-order-difference and log-linear methods differ in more than their numbers of parameters. For example, because of differences in the functions being optimized in the two methods, only the log-linear method exactly preserves as many moments of a distribution as there are non-constant terms in the polynomial--a distributional property which equipercentile equating is intended to preserve.

Appendix G

Log-linear Smoothing of the Test Distributions from the Operational Calibration of the ASVAB 15/16/17

Lower/Upper Bounds (Up To 10) of
Polynomial Degree Producing Statistically Significant*
Improvement in Likelihood-Ratio Chi-Square

Test	15a	15b	15c	16a	16b	17a	17b
GS	6/6	6/6	2/6	2/4	2/8	4/4	6/9
AR	4/4	4/10	4/4	3/8	4/6	4/4	4/4
WK	5/8	6/6	3/10	4/4	3/6	2/10	3/8
PC	5/5	6/9	4/4	4/10	4/7	4/4	5/5
NO	4/9	4/6	5/8	4/8	4/9	4/8	4/8
CS	5/5	5/5	5/7	5/7	5/5	5/10	5/7
AS	5/5	4/4	6/6	4/4	6/6	4/4	4/6
MK	4/4	4/7	4/10	4/8	4/8	5/5	4/4
MC	2/4	2/9	4/7	2/4	2/4	2/5	2/4
EI	5/5	5/5	2/4	4/4	4/4	4/10	4/4
VE	8/8	6/6	4/6	4/6	6/10	2/6	4/4

* Alpha = .05 with d.f. = 1.

Appendix H

Estimation of the Lower Tail of the Test Cumulative Distribution for Equipercentile Equating

Let Fi be the proportion of the population at or below test score i, i=0,...,m, where m is the number of items in the test.

Let fi be the proportion of a population of subjects at test score i, or fi = Fi - F(i-1)

Let u in $0 < u < m$ be the lowest (integer) score above j, where Fj = .005.

Let $Fi = [(i+1)/(u+1)]^c Fu.$ (1)

Then $c = \ln [1 - fu/Fu] / \ln [u/(u+1)]$ (2)

Proof:

If i = u, then $[(i+1)/(u+1)] = 1$ and Fi = Fu in (1).

If i = u, then, from (1), $F(u-1) = [u/(u+1)]^c Fu$

and $fu = Fu - F(u-1) = Fu - [u/(u+1)]c\ Fu$

$= Fu \{1 - [u/(u+1)]^c\}.$

Dividing by Fu, transposing terms, and taking logarithms yields

$c \ln [u/(u+1)] = \ln [1 - fu/Fu].$

Dividing by $\ln [u/(u+1)]$ yields (2).

Appendix I

Choosing among Alternative Equatings

In their discussion of evaluating an observed-score equating, Braun and Holland (1982) stated that, if there exists a population for which the reference-form (here, the vertical-response answer sheet) distribution differs from the equated new-form (here, the circular-response answer sheet) distribution, then the forms have not been equated. This implies two metrics in which equatings can be compared. The first is the *score* metric, in which the (cumulative) frequency is held constant and equated scores are compared. This is a type of comparison often used in a close study of alternative equatings (e.g., to see how different a linear equating is from an equipercentile equating). If various equatings provide similar equated scores, they are considered equally acceptable from the perspective of the examinee.

The second metric implied by Braun and Holland is the *frequency* metric, in which the score is held constant (e.g., at integer values on the reference form) and the cumulative distributions of the equated scores and reference form scores are compared. This is a type of comparison used to assess whether implementing an equated new form will change the score distributions (e.g., to see if there will be a change in the percent of persons qualifying for employment). If various equatings have no effect on the score distributions, they are considered equally acceptable from the perspective of the employing institution (Sympson, 1985).

Two criteria can be used to assess differences among the alternative equatings in the *score* metric:

- The first criterion is the root mean squared difference between a pair of equatings, with the difference at each score level weighted by the proportion of cases at that level on the circular-response answer sheet. The first criterion is an index of the algebraic difference between two sets of equated scores.

- The second criterion is the proportion of cases (from the circular-response-answer-sheet distribution) for which the two equatings differ by more than 0.5 standard score points (U.S. Department of Defense, 1988). The second criterion is an indicator of the practical impact of using one equating instead of the other.

Similarly, two criteria can be used to assess differences among alternative equatings in the *frequency* metric.

- The first criterion is the root mean squared difference between the cumulative distribution of equated scores (after linear interpolation at integer scores on the vertical-response answer sheet) and the cumulative distribution of scores on the vertical-response answer sheet, with the difference at each score level weighted by the proportion of cases at that level on the vertical-response answer sheet. The first criterion is an index of the algebraic difference between the equated-score and reference distributions.

- The second criterion is the proportion of cases (from the vertical-response answer sheet distribution) for which the cumulative proportions differ by more than 0.01. The second criterion is an indicator of the practical impact (on the score distribution) of using the equated

circular-response answer sheet instead of the vertical-response answer sheet.

A procedure for choosing among alternative equatings is to use the two root-mean-squared-difference indices (in the score metric and in the frequency metric) to select the linear or smoothed-distribution equating with the best fit to the raw equipercentile equating. Then, the two indices of impact (in the score metric and in the frequency metric) can be used to assess whether an equating with fewer parameters could be employed without having a practical consequence for the equated scores or their cumulative distribution.

The following heuristics implement this procedure for selecting an equating for the ASVAB tests. They specify cut points on the indices employed to compare equatings. The cut points have been chosen from a visual inspection of the results of applying them to the data from the OPCAL of the ASVAB 15/16/17. In choosing the points, an effort was made to provide some choice among alternative equatings where it seemed reasonable to have a choice (e.g., where two equatings with differing numbers of parameters provided visually similar equatings and visually similar equated-score distributions). An advantage of using cut points as specific as these is that the selection procedure can be replicated and evaluated. A disadvantage of this approach is that the cut points based on a study of military recruits may not result in the selection of the best equating for the population of military applicants, in which the equating will be used. More research is required to assess the inferential validity of the selected equating for the applicant population. Until such research provides further reassurances about these cut points or provides more defensible alternatives, the last step, (e), in the heuristics provides a necessary confirmation that the selected equating is accurate at least for the test and sample in which the equating was developed.

The heuristics are:

- (a) Select the smooth equating that minimizes the root-mean-squared-discrepancy between the smooth equating (linear or smoothed-equipercentile) and the raw equipercentile equating; then,

- (b) Compare the smooth equating from (a) with other smooth equatings that use fewer parameters; select the equating with the fewest parameters if it reduces the root-mean squared-discrepancy in the frequency metric by at least 10% without increasing the root-mean-squared-discrepancy in the score metric by more than 10%; if no such alternative smooth equating exists, use the selection from (a) as the best-fitting alternative; then,

- (c) Compare the equating selected in (b) with other smooth equatings that use fewer parameters; find those equatings with fewer parameters that also differ from (b) by more than 0.5 standard score points for fewer than 10% of the cases; then,

- (d) Select that equating from (c) that uses the fewest parameters and that results in fewer than 10% of the cases at scores where the equated cumulative distribution differs from the reference cumulative distribution by more than 0.01; then,

- (e) Graphically inspect the differences among the selected equating, the raw equipercentile equating, the identity equating, and (if it is not selected) the linear equating; also graphically inspect the differences among the reference cumulative distribution (for the vertical-response answer sheet) and the distributions of equated scores based on the selected equating, the raw equipercentile equating, the identity equating and (if it is not selected) the linear equating.

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ASVAB OMR OPCAL SUPPLEMENT

Tables 1-43 and Figures 1-13

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ASVAB OMR OPCAL SUPPLEMENT TABLES 1-43

Table 1

The ASVAB Tests, Numbers of Items, Time Limits, Normative Means, and Standard Deviations*

Tests (In order of administration)	No. Items	Time: Minutes	Mean	S.D.
General Science (GS)	25	11	15.950	5.010
Arithmetic Reasoning (AR)	30	36	18.009	7.373
Word Knowledge (WK)	35	11	26.270	7.710
Paragraph Comprehension (PC)	15	13	11.011	3.355
Numerical Operations (NO)	50	3	37.236	10.800
Coding Speed (CS)	84	7	47.606	16.763
Auto and Shop Information (AS)	25	11	14.317	5.550
Mathematics Knowledge (MK)	25	24	13.578	6.393
Mechanical Comprehension (MC)	25	19	14.165	5.349
Electronics Information (EI)	20	9	11.569	4.236
Verbal (VE = WK + PC)	50	-	37.281	10.595

* Means and standard deviations are from an administration of the reference form to a sample from 18-23-year-old American youth population (Department of Defense, 1982).

Table 2

Number of Subjects by Location, Date,
Type of Answer Sheet, and Phase of Study*

Phase I

	Vertical-Response Answer Sheet	Circular-Response Answer Sheet	Total
Army: Ft. Jackson April 2-May 25, 1990	1,379	1,375	2,754
Navy: San Diego RTC April 2-July 2, 1990	909	914	1,823
Air Force: Lackland AFB April 2-May 4, 1990	521	522	1,043
Marine Corps: San Diego April 30-May 11, 1990	393	392	785
Totals	3,202	3,203	6,405

Phase II

	Circular-Response Enlistment Answer Sheet	Circular-Response Student Answer Sheet	Total
Army: Ft. Jackson	146	147	293
Navy: San Diego RTC	92	90	182
Air Force: Lackland AFB	60	60	120
Marine Corps: San Diego	63	54	117
Totals	361	351	712

* From manual counts of answer sheets.

Table 3

Phase I Initial Response-Scanning Discrepancies Across N Subjects and m Items, by Test and Type of Answer Sheet

		Vertical-Response Answer Sheet (N = 289)		Circular-Response Answer Sheet (N = 304)	
Test	m	Frequency	Percentage	Frequency	Percentage
GS	25	3	.04	4	.05
AR	30	15	.17	9	.10
WK	35	5	.05	2	.02
PC	15	2	.05	4	.09
NO	50	15	.10	30	.20
CS	84	70	.29	4	.02
AS	25	13	.18	1	.03
MK	25	14	.19	1	.03
MC	25	10	.14	4	.05
EI	20	6	.10	1	.02

Table 4

Phase I Initial Number of Test Score Discrepancies Across N Subjects, by Test and Type of Answer Sheet

	Vertical-Response Answer Sheet (N = 289)		Circular-Response Answer Sheet (N = 304)	
Test	Frequency	Percentage	Frequency	Percentage
GS	1	0.35	1	0.33
AR	2	0.69	3	0.99
WK	2	0.69	2	0.66
PC	2	0.69	3	0.99
NO	9	3.11	8	2.63
CS	40	13.84	3	0.99
AS	8	2.77	0	0.00
MK	10	3.46	1	0.33
MC	7	2.42	3	0.99
EI	2	0.69	1	0.33

Table 5

Changes in Test Raw Score Means
after Phase I Rescanning,
by Test and Type of Answer Sheet

Test	Mean Change* Vertical-Response Answer Sheet	Circular-Response Answer Sheet
GS	-.001	-.002
AR	-.001	-.004
WK	.001	-.003
PC	.002	.000
NO	-.001	.047
CS	.162	.010
AS	.019	-.004
MK	.018	-.002
MC	.022	-.004
EI	.003	-.002
VE	.002	-.003
Sample Sizes:		
Initial Scan	3,162	3,158
Rescan	3,148	3,160

* Rescan Mean - Initial Scan Mean. Means and sample sizes after removing subjects with aberrantly low raw scores.

Table 6

Phase I Expected Number Right from Pure Guessing
and Percentage of Subjects with Scores Below this Level,
by Test and Type of Answer Sheet

Test	Expected Number Right From Pure Guessing	Percentage At or Below Expectation	
		Vertical-Response Answer Sheet	Circular-Response Answer Sheet
GS	6.25	0.7	0.8
AR	7.50	2.4	2.4
WK	8.75	0.2	0.2
PC	3.75	1.6	1.2
NO	12.50	0.8	0.6
CS	16.80	0.5	0.7
AS	6.25	3.4	2.9
MK	6.25	4.3	4.2
MC	6.25	3.6	3.6
EI	5.00	4.1	4.5

Table 7

Phase I Distribution of Number of Tests with Scores Below Pure-guessing Expectation, by Type of Answer Sheet

Number of Test Scores Below Expectation	Vertical-Response Answer Sheet		Circular-Response Answer Sheet	
	Frequency	Percentage	Frequency	Percentage
0	2,760	86.4	2,778	86.7
1	313	9.8	300	9.4
2	75	2.3	82	2.6
3	20	0.6	15	0.5
4	3	0.1	5	0.2
5	6	0.2	7	0.2
6	5	0.2	10	0.3
7	7	0.2	4	0.1
8	3	0.1	3	0.1
9	2	0.1	0	0.0
10	1	0.0	0	0.0
Totals	3,195		3,204	

Table 8

Phase I Gender, Ethnicity, and Educational level, by Type of Answer Sheet

	Vertical-Response Answer Sheet		Circular-Response Answer Sheet	
Classification	Frequency	Percentage	Frequency	Percentage
Gender				
Male	2,564	81.4	2,553	81.2
Female	584	18.6	593	18.8
Subtotals	3,148		3,146	
No Identifiable Response	0		14	
Ethnicity				
Caucasian	2,037	65.7	2,076	66.2
Non-Caucasian	1,064	34.3	1,061	33.8
Subtotals	3,101		3,137	
No Identifiable Response	47		23	
Education				
Non-High-School Graduate	421	13.4	394	12.6
High School Graduate	1,826	58.3	1,889	60.3
Post-Secondary	887	28.3	852	27.2
Subtotals	3,134		3,135	
No Identifiable Response	14		25	
Totals	3,148		3,160	

Table 9

Phase I Percentage of Matching SSNs,
Pre-enlistment ASVAB Standard Score Means,
Standard Deviations, t-ratios, and Effect-size Estimates

		Vertical-Response Answer Sheet	Circular-Response Answer Sheet	t-ratio	Effect Size*
	N Total	3,148	3,160		
	N Matched SSNs	3,094	3,119		
	Percentage Matched	98.3	98.7		
GS	Mean	52.56	52.36	1.06	.020
	Variance	55.667	57.236		
AR	Mean	53.09	52.98	.61	.011
	Variance	50.923	51.265		
NO	Mean	54.27	54.16	.65	.011
	Variance	45.525	45.040		
CS	Mean	53.58	53.51	.39	.007
	Variance	51.062	50.163		
AS	Mean	52.32	52.08	1.09	.024
	Variance	74.924	76.820		
MK	Mean	53.73	53.69	.21	.004
	Variance	59.150	58.392		
MC	Mean	53.76	53.40	1.74	.036
	Variance	66.250	68.613		
EI	Mean	51.73	51.60	.62	.013
	Variance	69.374	67.565		
VE	Mean	53.74	53.53	1.69	.021
	Variance	23.299	25.303		
AFQT**	Mean	60.37	59.86	1.07	.018
	Variance	343.189	357.866		

* Normative S.D. of subtests = 10; S.D. of AFQT = 28.6

** AFQT scores in percentile metric.
WK and PC subtests not included in this analysis.
(See text for explanation)

Table 10

Phase I Speed Test Means, Variances, t-ratios, and Effect-size Estimates

Test		Vertical-Response Answer Sheet	Circular-Response Answer Sheet	t-ratio	Effect Size*
NO					
	Mean	43.051	40.171	15.025**	.267 (.255)
	Variance	52.443	63.483		
	N	3,148	3,160		
CS					
	Mean	55.572	53.936	4.861**	.098 (.091)
	Variance	181.072	176.098		
	N	3,148	3,160		

* [Mean(Vertical) - Mean(Circular)] / S.D.(Normative)
Net effect size in parentheses: Effect size from this table, minus effect size from Table 9.

** P < .001

Table 11

Phase I Power Test Means, Variances, Chi-squares, t-ratios, and Effect-size Estimates

Test**		Vertical-Response Answer Sheet	Circular-Response Answer Sheet	Chi-Square	t-ratio	Effect Size*
GS				2.511		
	Mean	16.932	16.846		.875	.017
	Variance	14.923	15.591			(-.003)
AR				2.232		
	Mean	18.842	18.664		1.218	.024
	Variance	34.389	33.601			(.013)
AS				.781		
	Mean	15.714	15.654		.489	.011
	Variance	23.238	23.748			(-.013)
MK				3.371		
	Mean	15.184	15.032		1.178	.024
	Variance	26.958	25.952			(.020)
MC				.929		
	Mean	15.379	15.271		.882	.020
	Variance	23.890	23.704			(-.016)
EI				1.688		
	Mean	12.143	12.126		.195	.004
	Variance	11.752	12.235			(-.009)
VE				7.951		
	Mean	39.906	39.585		2.012	.030
	Variance	36.171	40.288			(.009)

* [Mean(Vertical) - Mean(Circular)] / S.D.(Normative)
Net effect size in parentheses:
Effect size from this table, minus effect size from Table 9

** WK and PC subtests not included in this analysis.
(See text for explanation)

Table 12

Phase I NO Means, Variances, Skewness, Kurtosis,
Sample Sizes, and Frequency Distributions

Vertical-Response Answer Sheet

Sample size	3,148
Mean	43.05110
Standard Deviation	7.24172
Skewness	-1.15026
Kurtosis	0.80207

no.rt.	freq.	no.rt.	freq.
0	0	41	90
1	0	42	113
2	0	43	115
3	0	44	114
4	0	45	126
5	0	46	140
6	0	47	205
7	0	48	268
8	0	49	438
9	0	50	553
10	2		
11	0		
12	1		
13	1		
14	0		
15	1		
16	1		
17	1		
18	5		
19	6		
20	3		
21	10		
22	8		
23	14		
24	12		
25	20		
26	20		
27	23		
28	27		
29	27		
30	38		
31	49		
32	56		
33	62		
34	47		
35	82		
36	74		
37	93		
38	108		
39	100		
40	95		

Circular-Response Answer Sheet

Sample Size	3,160
Mean	40.17090
Standard Deviation	7.96764
Skewness	-0.58028
Kurtosis	-0.44227

no.rt.	freq.	no.rt.	freq.
0	0	41	130
1	0	42	109
2	0	43	97
3	0	44	99
4	0	45	105
5	0	46	126
6	0	47	160
7	0	48	216
8	0	49	265
9	0	50	336
10	0		
11	0		
12	2		
13	1		
14	2		
15	3		
16	6		
17	0		
18	10		
19	2		
20	6		
21	14		
22	17		
23	27		
24	19		
25	33		
26	34		
27	49		
28	61		
29	63		
30	80		
31	61		
32	101		
33	92		
34	120		
35	126		
36	101		
37	109		
38	126		
39	131		
40	121		

Table 13

Unrounded Standard Score Equivalents of NO Number-Right on Circular-Response Answer Sheet, by Method of Equating

no. rt.	raw freq.	raw equip.	lin. ident.	lin. resc.	quar lg-ln	poly lg-ln	constr-dif.
0	0	15.981669	15.522222	21.577881	15.811416	15.972420	15.885142
1	0	16.908513	16.448148	22.419447	16.745595	16.914224	16.814444
2	0	17.837801	17.374074	23.261014	17.715323	17.875165	17.769683
3	0	18.768890	18.300000	24.102580	18.707995	18.872906	18.750280
4	0	19.707546	19.225926	24.944148	19.697036	19.898482	19.703769
5	0	20.654905	20.151852	25.785713	20.659894	20.943706	20.658550
6	0	21.610703	21.077778	26.627278	21.633106	22.002878	21.623230
7	0	22.574094	22.003704	27.468843	22.614306	23.072168	22.596076
8	0	23.544090	22.929630	28.310407	23.601712	24.148981	23.575581
9	0	24.519743	23.855556	29.151981	24.594002	25.231519	24.560519
10	0	25.500222	24.781481	29.993546	25.590185	26.277954	25.549917
11	0	26.484815	25.707407	30.835111	26.589509	27.329046	26.542991
12	2	27.472926	26.633333	31.676676	27.591398	28.387176	27.539139
13	1	28.464056	27.559259	32.518241	28.595417	29.451204	28.537870
14	2	29.457796	28.485185	33.359806	29.601213	30.520231	29.538787
15	3	30.453796	29.411111	34.201370	30.608500	31.593509	30.541556
16	6	31.451759	30.337037	35.042944	31.617065	32.522222	31.545935
17	0	32.451444	31.262963	35.884509	32.626722	33.303278	32.551704
18	10	33.864148	32.188889	36.726074	33.623991	34.035324	33.632676
19	2	34.865287	33.114815	37.567639	34.613574	34.771444	34.730500
20	6	35.234250	34.040741	38.409204	35.605519	35.547769	35.430241
21	14	36.338417	34.966667	39.250769	36.622259	36.398806	36.357537
22	17	37.381250	35.892593	40.092333	37.649630	37.353750	37.422787
23	27	38.726361	36.818519	40.933907	38.689565	38.428769	38.582102
24	19	39.787139	37.744444	41.775472	39.743898	39.614870	39.707917
25	33	40.865352	38.670370	42.617037	40.814315	40.874852	40.876083
26	34	42.027583	39.596296	43.458602	41.902269	42.117361	42.082444
27	49	43.269269	40.522222	44.300167	42.985843	43.317843	43.265009
28	61	44.415454	41.448148	45.141731	44.091019	44.472167	44.377296
29	63	45.470870	42.374074	45.983296	45.219556	45.577287	45.461046
30	80	46.551037	43.300000	46.824870	46.370509	46.630500	46.563352
31	61	47.734907	44.225926	47.666435	47.536389	47.659370	47.663861
32	101	48.673463	45.151852	48.508000	48.708083	48.680778	48.717481
33	92	49.762370	46.077778	49.349565	49.888898	49.705241	49.745472
34	120	50.734657	47.003704	50.191130	51.065556	50.740648	50.760963
35	126	51.834361	47.929630	51.032694	52.214880	51.791741	51.796120
36	101	52.922620	48.855556	51.874259	53.317157	52.859741	52.868056
37	109	53.984056	49.781481	52.715833	54.355583	53.940954	53.963870
38	126	54.941991	50.707407	53.557398	55.312407	55.020111	55.040194
39	131	55.974204	51.633333	54.398963	56.177750	56.067157	56.069324
40	121	56.968204	52.559259	55.240528	56.953500	57.029083	56.991176
41	130	57.863444	53.485185	56.082093	57.655435	57.858111	57.765417
42	109	58.627639	54.411111	56.923657	58.248167	58.553259	58.371528
43	97	59.091093	55.337037	57.765222	58.798176	59.064019	58.857630
44	99	59.525389	56.262963	58.606796	59.301343	59.542185	59.290639
45	105	59.876454	57.188889	59.448361	59.757704	59.891944	59.689380
46	126	60.273981	58.114815	60.289926	60.204444	60.278065	60.084111
47	160	60.635546	59.040741	61.131491	60.633000	60.633630	60.528981
48	216	61.031463	59.966667	61.973056	61.065972	61.023287	60.974769
49	265	61.500019	60.892593	62.814620	61.524296	61.498194	61.484611
50	336	62.001259	61.818519	63.656194	62.005315	62.003972	62.002046

Table 14

Phase I CS Means, Variances, Skewness, Kurtosis, Sample Sizes, and Frequency Distributions

Vertical-Response Answer Sheet

Sample size	3,148
Mean	55.57210
Standard Deviation	13.45630
Skewness	-0.06639
Kurtosis	-0.04693

no.rt.	freq.	no.rt.	freq.
0	0	43	57
1	1	44	58
2	0	45	62
3	0	46	75
4	0	47	78
5	0	48	71
6	0	49	105
7	0	50	89
8	0	51	83
9	1	52	104
10	1	53	107
11	0	54	88
12	0	55	125
13	1	56	108
14	1	57	83
15	0	58	83
16	1	59	80
17	5	60	77
18	3	61	87
19	4	62	72
20	5	63	96
21	3	64	60
22	1	65	68
23	10	66	67
24	7	67	49
25	9	68	61
26	4	69	52
27	13	70	61
28	12	71	32
29	12	72	45
30	16	73	36
31	11	74	39
32	16	75	24
33	11	76	26
34	22	77	20
35	26	78	18
36	25	79	22
37	37	80	27
38	36	81	17
39	40	82	28
40	62	83	44
41	56	84	51
42	61		

Circular-Response Answer Sheet

Sample Size	3,160
Mean	53.93640
Standard Deviation	13.27020
Skewness	0.02432
Kurtosis	0.11173

no.rt.	freq.	no.rt.	freq.
0	0	43	63
1	0	44	68
2	0	45	68
3	0	46	93
4	0	47	89
5	0	48	81
6	0	49	97
7	0	50	112
8	0	51	96
9	0	52	88
10	0	53	97
11	2	54	113
12	4	55	99
13	1	56	124
14	2	57	85
15	3	58	80
16	2	59	100
17	4	60	92
18	5	61	78
19	1	62	80
20	5	63	88
21	6	64	56
22	3	65	55
23	4	66	48
24	13	67	36
25	8	68	50
26	9	69	45
27	8	70	44
28	10	71	23
29	7	72	29
30	15	73	26
31	15	74	24
32	21	75	18
33	23	76	10
34	22	77	28
35	40	78	11
36	37	79	20
37	41	80	26
38	36	81	14
39	48	82	26
40	57	83	31
41	68	84	50
42	79		

Table 15

Unrounded Standard Score Equivalents of CS Number-Right on Circular-Response Answer Sheet, by Method of Equating

no. rt.	raw freq.	raw equip.	lin. ident.	lin. resc.	quar lg-ln	poly lg-ln	constr-dif.
0	0	21.788507	21.600549	22.125098	21.647969	21.769875	21.314403
1	0	22.389242	22.197101	22.730016	22.270248	22.389413	21.910953
2	0	23.010564	22.793653	23.334933	22.905659	23.047370	22.507229
3	0	23.646526	23.390205	23.939851	23.543171	23.702511	23.101500
4	0	24.286589	23.986757	24.544769	24.181391	24.344801	23.691896
5	0	24.903700	24.583308	25.149687	24.819933	24.996936	24.072528
6	0	25.527304	25.179860	25.754605	25.458651	25.655735	24.505750
7	0	26.155998	25.776412	26.359523	26.094225	26.319215	25.018181
8	0	26.788693	26.372964	26.964441	26.728046	26.986094	25.559896
9	0	27.424561	26.969516	27.569361	27.362862	27.655515	26.114252
10	0	28.062978	27.566068	28.174277	27.998413	28.326875	26.674656
11	2	28.703460	28.162620	28.779192	28.634534	28.999761	27.095570
12	4	29.345636	28.759172	29.384114	29.271091	29.670053	27.561176
13	1	29.989226	29.355724	29.989029	29.907994	30.331229	28.062304
14	2	30.633997	29.952276	30.593951	30.545183	30.994655	28.584215
15	3	31.279765	30.548828	31.198867	31.182599	31.659977	29.119024
16	2	31.926385	31.145380	31.803782	31.820211	32.304074	29.662214
17	4	32.807863	31.741932	32.408704	32.457985	32.920235	30.121917
18	5	33.522299	32.338484	33.013619	33.041788	33.506019	30.338024
19	1	33.911543	32.935035	33.618541	33.591183	34.057096	30.383255
20	5	34.664660	33.531587	34.223456	34.140709	34.591827	30.428491
21	6	35.313995	34.128139	34.828372	34.697930	35.116692	30.473722
22	3	35.581423	34.724691	35.433294	35.262507	35.637171	30.518958
23	4	35.862238	35.321243	36.038209	35.833956	36.150671	30.564189
24	13	36.502136	35.917795	36.643125	36.411722	36.667017	30.609426
25	8	37.490670	36.514347	37.248046	36.995240	37.191648	30.654662
26	9	37.879246	37.110899	37.852962	37.583935	37.727006	30.699893
27	8	38.289656	37.707451	38.457883	38.177271	38.274772	30.745129
28	10	38.735370	38.304003	39.062799	38.774748	38.835865	30.790360
29	7	39.156320	38.900555	39.667715	39.375905	39.410416	30.835596
30	15	39.575523	39.497107	40.272636	39.980338	39.997823	30.858235
31	15	40.285975	40.093659	40.877552	40.587681	40.596850	30.873173
32	21	40.987657	40.690211	41.482473	41.197614	41.205769	30.888105
33	23	41.880451	41.286763	42.087389	41.809867	41.822544	30.903036
34	22	42.441067	41.883314	42.692304	42.424190	42.445010	30.917974
35	40	43.164499	42.479866	43.297226	43.040381	43.071043	30.932906
36	37	43.851047	43.076418	43.902142	43.658241	43.698717	30.995955
37	41	44.491517	43.672970	44.507063	44.277611	44.326397	31.059011
38	36	45.071151	44.269522	45.111979	44.898348	44.952795	31.122060
39	48	45.506801	44.866074	45.716894	45.520319	45.577015	58.689369
40	57	46.036718	45.462626	46.321816	46.143405	46.198527	60.206962
41	68	46.671908	46.059178	46.926731	46.767500	46.817145	60.207618
42	79	47.418433	46.655730	47.531653	47.392495	47.432971	60.207791

continued

Table 15
(continued)

Unrounded Standard Score Equivalents of CS Number-Right
on Circular-Response Answer Sheet,
by Method of Equating

no. rt.	raw freq.	raw equip.	lin. ident.	lin. resc.	quar lg-ln	poly lg-ln	constr-dif.
43	63	48.148130	47.252282	48.136569	48.018296	48.046346	60.207922
44	68	48.770363	47.848834	48.741484	48.644801	48.657806	60.208513
45	68	49.309181	48.445386	49.346406	49.271932	49.268019	60.209109
46	93	49.923707	49.041938	49.951321	49.899576	49.877743	60.209241
47	89	50.635286	49.638490	50.556237	50.527650	50.487783	60.209372
48	81	51.116375	50.235041	51.161159	51.155318	51.098956	60.209503
49	97	51.708232	50.831593	51.766074	51.783481	51.712050	60.209640
50	112	52.428456	51.428145	52.370996	52.412223	52.327722	60.210547
51	96	53.019853	52.024697	52.975911	53.041419	52.946609	60.211889
52	88	53.534015	52.621249	53.580827	53.670906	53.569546	60.212981
53	97	54.145052	53.217801	54.185748	54.300525	54.196868	60.213649
54	113	54.644258	53.814353	54.790664	54.930060	54.828652	60.215290
55	99	55.217318	54.410905	55.395586	55.559285	55.464702	60.217157
56	124	55.989035	55.007457	56.000501	56.187932	56.104498	60.218141
57	85	56.746203	55.604009	56.605417	56.815689	56.747241	60.218893
58	80	57.369331	56.200561	57.210338	57.442200	57.391803	57.391803
59	100	58.021195	56.797113	57.815254	58.067064	58.036837	58.036837
60	92	58.757889	57.393665	58.420175	58.689805	58.680809	58.680809
61	78	59.315868	57.990217	59.025091	59.309909	59.322114	59.322114
62	80	59.998908	58.586768	59.630007	59.926785	59.959142	59.959142
63	88	60.743363	59.183320	60.234928	60.539772	60.590413	60.590413
64	56	61.422681	59.779872	60.839844	61.148154	61.214604	61.214604
65	55	62.050946	60.376424	61.444759	61.751148	61.830639	61.830639
66	48	62.567971	60.972976	62.049681	62.347921	62.437672	62.437672
67	36	63.047969	61.569528	62.654596	62.937607	63.035077	63.035077
68	50	63.468800	62.166080	63.259518	63.519322	63.622401	63.622401
69	45	64.179974	62.762632	63.864434	64.092221	64.199230	64.199230
70	44	64.789047	63.359184	64.469349	64.655515	64.765155	64.765155
71	23	65.326684	63.955736	65.074271	65.208555	65.319627	65.319627
72	29	65.732142	64.552288	65.679186	65.750874	65.861934	65.861934
73	26	66.218386	65.148840	66.284108	66.282282	66.391261	66.391261
74	24	66.822263	65.745392	66.889023	66.802929	66.906842	66.906842
75	18	67.321917	66.341944	67.493939	67.313422	67.408441	67.408441
76	10	67.737911	66.938495	68.098861	67.815463	67.897113	67.897113
77	28	68.354608	67.535047	68.703776	68.311973	68.378208	68.378208
78	11	68.895055	68.131599	69.308698	68.801629	68.851292	68.851292
79	20	69.260550	68.728151	69.913613	69.286745	69.316751	69.316751
80	26	69.851387	69.324703	70.518529	69.770256	69.782909	69.782909
81	14	70.420503	69.921255	71.123450	70.255605	70.261248	70.261248
82	26	70.834481	70.517807	71.728366	70.745475	70.746853	70.746853
83	31	71.219418	71.114359	72.333288	71.242391	71.237117	71.237117
84	50	71.717873	71.710911	72.938203	71.750767	71.742230	71.742230

Table 16

Indices for Selection of Equating Function: NO

Root Mean Square Difference

Score Metric: Difference Between Smooth Equating and Raw Equipercentile Equating

Linear Rescaling	1.266
Quartic Log-Linear	0.217
Polynomial Log-Linear	0.091
Constrained Second-Order	0.106

Frequency Metric: Difference Between Cumulative Distributions of Equated Scores and Reference Form

Linear Rescaling	0.075
Quartic Log-Linear	0.009
Polynomial Log-Linear	0.001
Constrained Second-Order	0.008

Impact of Difference

Score Metric: Percentage of Cases For Which Equated Score Scales Differ By More Than 0.5

Linear Rescaling vs. Quartic Log-Linear	80.27
Linear Rescaling vs. Polynomial Log-Linear	75.35
Linear Rescaling vs. Constrained Second-Order	82.43
Quartic Log-Linear vs. Polynomial Log-Linear	0.44
Quartic Log-Linear vs. Constrained Second-Order	0.00
Polynomial Log-Linear vs. Constrained Second-Order	0.44

Frequency Metric: Percentage of Cases At Score Levels Where Equated-Score Distribution and Reference Form Distribution Differ By More Than 0.01

Linear Rescaling	91.87
Quartic Log-Linear	27.26
Polynomial Log-Linear	0.00
Constrained Second-Order	15.03

Table 17

Indices for Selection of Equating Function: CS

Root Mean Square Difference

Score Metric: Difference Between Smooth Equating and Raw Equipercentile Equating

Linear Rescaling	0.332
Quartic Log-Linear	0.154
Polynomial Log-Linear	0.120
Constrained Second-Order	7.385*

Frequency Metric: Difference Between Cumulative Distributions of Equated Scores and Reference Form

Linear Rescaling	0.008
Quartic Log-Linear	0.006
Polynomial Log-Linear	0.004
Constrained Second-Order	0.291*

Impact of Difference

Score Metric: Percentage of Cases For Which Equated Score Scales Differ By More Than 0.5

Linear Rescaling vs. Quartic Log-Linear	5.65
Linear Rescaling vs. Polynomial Log-Linear	5.50
Linear Rescaling vs. Constrained Second-Order	67.95*
Quartic Log-Linear vs. Polynomial Log-Linear	0.00
Quartic Log-Linear vs. Constrained Second-Order	62.64*
Polynomial Log-Linear vs. Constrained Second-Order	62.64*

Frequency Metric: Percentage of Cases At Score Levels Where Equated-Score Distribution and Reference Form Distribution Differ By More Than 0.01

Linear Rescaling	22.46
Quartic Log-Linear	10.04
Polynomial Log-Linear	6.07
Constrained Second-Order	72.87*

* Constrained second-order estimate of distribution for circular-response answer sheet did not converge in programmed number of iterations.

Table 18

Conversion Table for the ASVAB Forms 8f/8g/9f/9g/10f/10g/13h/14f/14g/14h/15h/18h
Circular-Response Answer Sheet

For Test Scores GS, AR, WK, PC, NO, CS

RAW	GS	AR	WK	PC	NO	CS	RAW
0	20	26	20	20	20	22	0
1	20	27	20	20	20	22	1
2	22	28	20	23	20	23	2
3	24	30	20	26	20	24	3
4	26	31	21	29	20	24	4
5	28	32	22	32	21	25	5
6	30	34	24	35	22	26	6
7	32	35	25	38	23	26	7
8	34	36	26	41	24	27	8
9	36	38	28	44	25	28	9
10	38	39	29	47	26	28	10
11	40	40	30	50	27	29	11
12	42	42	31	53	28	30	12
13	44	43	33	56	29	30	13
14	46	45	34	59	31	31	14
15	48	46	35	62	32	32	15
16	50	47	37		33	32	16
17	52	49	38		33	33	17
18	54	50	39		34	34	18
19	56	51	41		35	34	19
20	58	53	42		36	35	20
21	60	54	43		36	35	21
22	62	55	44		37	36	22
23	64	57	46		38	36	23
24	66	58	47		40	37	24
25	68	59	48		41	37	25
26		61	50		42	38	26
27		62	51		43	38	27
28		64	52		44	39	28
29		65	54		46	39	29
30		66	55		47	40	30
31			56		48	41	31
32			57		49	41	32
33			59		50	42	33
34			60		51	42	34
35			61		52	43	35
36					53	44	36
37					54	44	37
38					55	45	38
39					56	46	39
40					57	46	40
41					58	47	41
42					59	47	42
43					59	48	43
44					60	49	44

RAW	GS	AR	WK	PC	NO	CS	RAW
45					60	49	45
46					60	50	46
47					61	50	47
48					61	51	48
49					61	52	49
50					62	52	50
51						53	51
52						54	52
53						54	53
54						55	54
55						55	55
56						56	56
57						57	57
58						57	58
59						58	59
60						59	60
61						59	61
62						60	62
63						61	63
64						61	64
65						62	65
66						62	66
67						63	67
68						64	68
69						64	69
70						65	70
71						65	71
72						66	72
73						66	73
74						67	74
75						67	75
76						68	76
77						68	77
78						69	78
79						69	79
80						70	80
81						70	81
82						71	82
83						71	83
84						72	84

continued

Table 18
(continued)

Conversion Table for the ASVAB Forms 8f/8g/9f/9g/10f/10g/13h/14f/14g/14h/15h/18h
Circular-Response Answer Sheet

For Test Scores AS, MK, MC, EI, VE

RAW	AS	MK	MC	EI	VE	RAW	RAW	AS	MK	MC	EI	VE	RAW
0	24	29	24	23	20	0	25	69	68	70		38	25
1	26	30	25	25	20	1	26					39	26
2	28	32	27	27	20	2	27					40	27
3	30	33	29	30	20	3	28					41	28
4	31	35	31	32	20	4	29					42	29
5	33	37	33	34	20	5	30					43	30
6	35	38	35	37	20	6	31					44	31
7	37	40	37	39	21	7	32					45	32
8	39	41	38	42	22	8	33					46	33
9	40	43	40	44	23	9	34					47	34
10	42	44	42	46	24	10	35					48	35
11	44	46	44	49	25	11	36					49	36
12	46	48	46	51	26	12	37					50	37
13	48	49	48	53	27	13	38					51	38
14	49	51	50	56	28	14	39					52	39
15	51	52	52	58	29	15	40					53	40
16	53	54	53	60	30	16	41					54	41
17	55	55	55	63	31	17	42					54	42
18	57	57	57	65	32	18	43					55	43
19	58	58	59	68	33	19	44					56	44
20	60	60	61	70	34	20	45					57	45
21	62	62	63		35	21	46					58	46
22	64	63	65		36	22	47					59	47
23	66	65	67		37	23	48					60	48
24	67	66	68		37	24	49					61	49
							50					62	50

Table 19

Correspondence of Current ASVAB Booklets with Form Designations under Vertical-Response and Circular-Response Answer Sheets

Test Booklet	Vertical-Response Answer Sheet	Circular-Response Answer Sheet
8a/b	8a/b	8f/g
9a/b	9a/b	9f/g
10a/b	10a/b	10f/g
11a/b	11a/b	11f/g
12a/b	12a/b	12f/g
13a/b/c	13a/b/c	13f/g/h
14a/b/c	14a/b/c	14f/g/h
15a/b/c	15a/b/c	15f/g/h
16a/b	16a/b	16f/g
17a/b	17a/b	17f/g
18a/b/c	18a/b/c	18f/g/h
19a/b	19a/b	19f/g

Table 20

Answer Sheet Number-Right Equivalents
and Equated Standard Score Equivalents
for NO on the ASVAB 15/16/17

		Standard Score Equivalents					
No.Rt.	No.Rt.Eqiv.	15f	15g	16f	16g	17f	17g
0	0.486214	20.000000	20.000000	20.000000	20.000000	20.000000	20.000000
1	1.503362	20.000000	20.000000	20.000000	20.000000	20.000000	20.000000
2	2.541178	20.000000	20.000000	20.000000	20.000000	20.000000	20.000000
3	3.618739	20.708656	20.000000	20.000000	20.000000	20.000000	20.000000
4	4.726361	21.697383	20.693805	20.000000	20.000000	20.000000	20.000000
5	5.855203	22.705052	21.724630	20.000000	20.180306	20.478556	20.518229
6	6.999108	23.726167	22.769210	20.063110	21.264695	21.547696	21.590109
7	8.153941	24.757036	23.823770	21.168991	22.359443	22.627050	22.672228
8	9.316900	25.795160	24.885750	22.282655	23.461893	23.713998	23.761962
9	10.486040	26.838801	25.953374	23.402237	24.570204	24.806723	24.857488
10	11.616190	27.847638	26.985394	24.484482	25.641553	25.863007	25.916479
11	12.751370	28.860964	28.022007	25.571544	26.717670	26.923992	26.980183
12	13.894150	29.881075	29.065560	26.665884	27.800992	27.992080	28.051009
13	15.043300	30.906872	30.114930	27.766324	28.890352	29.066122	29.127803
14	16.197850	31.937489	31.169231	28.871935	29.984832	30.145211	30.209658
15	17.356990	32.972204	32.227724	29.981941	31.083663	31.228590	31.295813
16	18.360000	33.867548	33.143643	30.942436	32.034487	32.166043	32.235669
17	19.203540	34.620540	33.913939	31.750220	32.834138	32.954450	33.026096
18	19.994150	35.326284	34.635901	32.507317	33.583613	33.693386	33.766926
19	20.789160	36.035955	35.361881	33.268628	34.337259	34.436434	34.511879
20	21.627590	36.784386	36.127510	34.071519	35.132066	35.220065	35.297517
21	22.546710	37.604845	36.966824	34.951679	36.003365	36.079111	36.158765
22	23.578050	38.525478	37.908613	35.939303	36.981045	37.043043	37.125168
23	24.739070	39.561871	38.968823	37.051109	38.081658	38.128179	38.213085
24	26.020060	40.705355	40.138585	38.277801	39.295999	39.325444	39.413418
25	27.380840	41.920065	41.381209	39.580900	40.585978	40.597284	40.688517
26	28.722750	43.117931	42.606602	40.865929	41.858069	41.851487	41.945935
27	30.019270	44.275279	43.790546	42.107492	43.087132	43.063267	43.160820
28	31.265940	45.388128	44.928968	43.301318	44.268939	44.228455	44.328995
29	32.459470	46.453541	46.018865	44.444257	45.400370	45.343976	45.447375
30	33.596940	47.468912	47.057569	45.533511	46.478658	46.407101	46.513225
31	34.708120	48.460814	48.072266	46.597591	47.532024	47.445655	47.554440
32	35.811240	49.445522	49.079603	47.653952	48.577750	48.476675	48.588103
33	36.917660	50.433176	50.089953	48.713473	49.626603	49.510780	49.624857
34	38.035900	51.431381	51.111097	49.784313	50.686662	50.555932	50.672688
35	39.171080	52.444708	52.147710	50.871375	51.762779	51.616917	51.736392
36	40.324520	53.474334	53.200998	51.975922	52.856206	52.694968	52.817207
37	41.492230	54.516699	54.267316	53.094136	53.963161	53.786357	53.911393
38	42.657720	55.557082	55.331607	54.210223	55.068011	54.875671	55.003498
39	43.788530	56.566507	56.364230	55.293100	56.139986	55.932572	56.063107
40	44.827410	57.493871	57.312904	56.287944	57.124814	56.903551	57.036575
41	45.722760	58.293112	58.130512	57.145342	57.973579	57.740381	57.875550
42	46.473520	58.963283	58.816084	57.864278	58.685278	58.442072	58.579039
43	47.025140	59.455691	59.319807	58.392516	59.208197	58.957638	59.095926
44	47.541560	59.916677	59.791386	58.887046	59.697748	59.440305	59.579830
45	47.919300	60.253869	60.136328	59.248775	60.055835	59.793356	59.933786
46	48.336310	60.626116	60.517129	59.648108	60.451148	60.183110	60.324539
47	48.720320	60.968905	60.867795	60.015841	60.815178	60.542021	60.684370
48	49.141150	61.344562	61.252085	60.418833	61.214113	60.935346	61.078703
49	49.654050	61.802406	61.720450	60.909992	61.700327	61.414723	61.559309
50	50.200290	62.290011	62.219261	61.433078	62.218146	61.925261	62.071155

Table 21

Answer Sheet Number-Right Equivalents
and Equated Standard Score Equivalents
for NO on the ASVAB 18/19

		Standard Score Equivalents	
No.Rt.	No.Rt.Eqiv.	18f/g	19f/g
0	0.486214	20.000000	20.000000
1	1.503362	20.135674	20.408677
2	2.541178	21.059510	21.323354
3	3.618739	22.018726	22.273059
4	4.726361	23.004702	23.249259
5	5.855203	24.009567	24.244161
6	6.999108	25.027841	25.252339
7	8.153941	26.055842	26.270148
8	9.316900	27.091077	27.295119
9	10.486040	28.131814	28.325538
10	11.616190	29.137844	29.321592
11	12.751370	30.148351	30.322080
12	13.894150	31.165623	31.329267
13	15.043300	32.188565	32.342067
14	16.197850	33.216315	33.359627
15	17.356990	34.248151	34.381232
16	18.360000	35.141003	35.265232
17	19.203540	35.891900	36.008684
18	19.994150	36.595680	36.705486
19	20.789160	37.303377	37.406166
20	21.627590	38.049725	38.145114
21	22.546710	38.867901	38.955179
22	23.578050	39.785972	39.864147
23	24.739070	40.819481	40.887410
24	26.020060	41.959784	42.016407
25	27.380840	43.171114	43.215727
26	28.722750	44.365647	44.398416
27	30.019270	45.519774	45.541100
28	31.265940	46.629526	46.639850
29	32.459470	47.691975	47.691765
30	33.596940	48.704520	48.694271
31	34.708120	49.693663	49.673607
32	35.811240	50.675631	50.645839
33	36.917660	51.660537	51.620979
34	38.035900	52.655964	52.606537
35	39.171080	53.666471	53.607025
36	40.324520	54.693232	54.623606
37	41.492230	55.732697	55.652765
38	42.657720	56.770185	56.679966
39	43.788530	57.776802	57.676603
40	44.827410	58.701585	58.592217
41	45.722760	59.498602	59.381332
42	46.473520	60.166908	60.043012
43	47.025140	60.657946	60.529181
44	47.541560	61.117649	60.984326
45	47.919300	61.453903	61.317247
46	48.336310	61.825114	61.684777
47	48.720320	62.166949	62.023224
48	49.141150	62.541561	62.394121
49	49.654050	62.998131	62.846164
50	50.200290	63.484379	63.327591

Table 22

Answer Sheet Number-Right Equivalents and Equated Standard Score Equivalents for CS on the ASVAB 15/16/17

No. Rt.	No. Rt. Equiv.	Standard Score Equivalents 15f/g	16f/g	17f/g
0	0.283842	21.671992	21.123304	20.828531
1	1.322373	22.286655	21.752372	21.456790
2	2.425306	22.939435	22.420451	22.124009
3	3.523520	23.589422	23.085670	22.788373
4	4.600190	24.226658	23.737841	23.439704
5	5.693363	24.873662	24.400007	24.101019
6	6.797708	25.527278	25.068940	24.769092
7	7.909900	26.185538	25.742627	25.441913
8	9.027790	26.847170	26.419765	26.118180
9	10.149940	27.511324	27.099484	26.797024
10	11.275340	28.177401	27.781171	27.477835
11	12.403300	28.844994	28.464409	28.160194
12	13.526910	29.510012	29.145012	28.839922
13	14.635240	30.165986	29.816359	29.510406
14	15.747340	30.824192	30.489990	30.183170
15	16.862620	31.484279	31.165547	30.857859
16	17.942320	32.123309	31.819553	31.511023
17	18.975190	32.734621	32.445192	32.135857
18	19.957140	33.315797	33.039987	32.729888
19	20.880910	33.862538	33.599541	33.288722
20	21.777280	34.393062	34.142499	33.830981
21	22.657110	34.913796	34.675437	34.363234
22	23.529590	35.430181	35.203923	34.891041
23	24.390370	35.939641	35.725322	35.411769
24	25.255920	36.451924	36.249611	35.935384
25	26.135360	36.972427	36.782313	36.467401
26	27.032780	37.503573	37.325906	37.010295
27	27.951000	38.047029	37.882099	37.565772
28	28.891560	38.603707	38.451823	38.134763
29	29.854680	39.173738	39.035212	38.717402
30	30.839350	39.756523	39.631655	39.313078
31	31.843500	40.350837	40.239898	39.920539
32	32.864230	40.954965	40.858183	40.538029
33	33.898130	41.566887	41.484446	41.163487
34	34.941570	42.184456	42.116488	41.794715
35	35.990990	42.805564	42.752152	42.429562
36	37.043160	43.428299	43.389482	43.066072
37	38.095340	44.051041	44.026817	43.702588
38	39.145370	44.672510	44.662851	44.337803
39	40.191750	45.291819	45.296673	44.970811
40	41.233590	45.908440	45.927746	45.601071
41	42.270580	46.522191	46.555881	46.228398
42	43.302890	47.133173	47.181180	46.852894
43	44.331090	47.741721	47.803991	47.474903
44	45.356080	48.348370	48.424857	48.094971
45	46.378980	48.953782	49.044457	48.713774
46	47.401060	49.558708	49.663560	49.332081
47	48.423670	50.163949	50.282984	49.950709
48	49.448180	50.770313	50.903560	50.570486
49	50.475910	51.378584	51.526085	51.192211
50	51.507960	51.989411	52.151228	51.816549
51	52.545400	52.603429	52.779635	52.444148
52	53.589630	53.221465	53.412155	53.075855
53	54.641210	53.843851	54.049127	53.712008
54	55.700270	54.470665	54.690631	54.352686
55	56.766480	55.101710	55.336465	54.997690
56	57.838970	55.736472	55.986103	55.646492
57	58.916400	56.374158	56.638733	56.298283
58	59.996880	57.013649	57.293211	56.951920
59	61.078150	57.653608	57.948167	57.606034
60	62.157640	58.292513	58.602045	58.259071
61	63.232660	58.928772	59.253216	58.909404
62	64.300510	59.560788	59.900044	59.555400
63	65.358710	60.187093	60.541026	60.195557
64	66.405040	60.806372	61.174818	60.828534
65	67.437700	61.417560	61.800330	61.453242
66	68.455270	62.019817	62.416701	62.068821
67	69.456700	62.612522	63.023296	62.674635
68	70.441230	63.195224	63.619654	63.270227
69	71.408170	63.767516	64.205358	63.855177
70	72.356830	64.328988	64.779989	64.429068
71	73.286290	64.879097	65.342989	64.991345
72	74.195360	65.417137	65.893639	65.541287
73	75.082670	65.942299	66.431108	66.078065
74	75.946940	66.453825	66.954622	66.600905
75	76.787770	66.951477	67.463937	67.109565
76	77.606930	67.436303	67.960125	67.605115
77	78.413390	67.913613	68.448621	68.092983
78	79.206420	68.382975	68.928982	68.572726
79	79.986670	68.844772	69.401602	69.044738
80	80.768090	69.307262	69.874931	69.517458
81	81.569930	69.781838	70.360629	70.002531
82	82.383950	70.263622	70.853704	70.494972
83	83.205780	70.750029	71.351510	70.992138
84	84.052500	71.251168	71.864393	71.504361

Table 23

Answer Sheet Number-Right Equivalents and Equated Standard Score Equivalents for CS on the ASVAB 18/19

No. Rt.	No.Rt. Equiv.	Standard Score Equivalents 18f/g	19f/g
0	0.283842	21.763778	22.224136
1	1.322373	22.390012	22.837639
2	2.425306	23.055081	23.489187
3	3.523520	23.717304	24.137947
4	4.600190	24.366536	24.773980
5	5.693363	25.025719	25.419762
6	6.797708	25.691639	26.072144
7	7.909900	26.362291	26.729161
8	9.027790	27.036379	27.389545
9	10.149940	27.713035	28.052445
10	11.275340	28.391652	28.717265
11	12.403300	29.071812	29.383597
12	13.526910	29.749349	30.047360
13	14.635240	30.417672	30.702096
14	15.747340	31.088268	31.359059
15	16.862620	31.760782	32.017900
16	17.942320	32.411841	32.655723
17	18.975190	33.034662	33.265882
18	19.957140	33.626778	33.845960
19	20.880910	34.183811	34.391669
20	21.777280	34.724322	34.921191
21	22.657110	35.254860	35.440943
22	23.529590	35.780965	35.956353
23	24.390370	36.300016	36.464851
24	25.255920	36.821942	36.976167
25	26.135360	37.352245	37.495688
26	27.032780	37.893389	38.025831
27	27.951000	38.447076	38.568261
28	28.891560	39.014233	39.123888
29	29.854680	39.594995	39.692843
30	30.839350	40.188751	40.274528
31	31.843500	40.794253	40.867720
32	32.864230	41.409754	41.470707
33	33.898130	42.033195	42.081475
34	34.941570	42.662390	42.697877
35	35.990990	43.295190	43.317813
36	37.043160	43.929649	43.939373
37	38.095340	44.564113	44.560939
38	39.145370	45.197281	45.181234
39	40.191750	45.828249	45.799374
40	41.233590	46.456478	46.414832
41	42.270580	47.081783	47.027424
42	43.302890	47.704266	47.637252
43	44.331090	48.324271	48.244652
44	45.356080	48.942340	48.850156
45	46.378980	49.559149	49.454425
46	47.401060	50.175463	50.058209
47	48.423670	50.792097	50.662307
48	49.448180	51.409876	51.267527
49	50.475910	52.029598	51.874649
50	51.507960	52.651924	52.484323
51	52.545400	53.277500	53.097182
52	53.589630	53.907171	53.714051
53	54.641210	54.541274	54.335263
54	55.700270	55.179887	54.960893
55	56.766480	55.822812	55.590747
56	57.838970	56.469523	56.224311
57	58.916400	57.119213	56.860793
58	59.996880	57.770743	57.499077
59	61.078150	58.422749	58.137827
60	62.157640	59.073681	58.775526
61	63.232660	59.721919	59.410584
62	64.300510	60.365832	60.041407
63	65.358710	61.003927	60.666529
64	66.405040	61.634864	61.284639
65	67.437700	62.257558	61.894674
66	68.455270	62.871153	62.495794
67	69.456700	63.475015	63.087380
68	70.441230	64.068687	63.668982
69	71.408170	64.651751	64.240193
70	72.356830	65.223794	64.800606
71	73.286290	65.784258	65.349676
72	74.195360	66.332427	65.886701
73	75.082670	66.867475	66.410871
74	75.946940	67.388630	66.921431
75	76.787770	67.895651	67.418144
76	77.606930	68.389604	67.902055
77	78.413390	68.875900	68.378464
78	79.206420	69.354097	68.846940
79	79.986670	69.824587	69.307865
80	80.768090	70.295784	69.769482
81	81.569930	70.779293	70.243162
82	82.383950	71.270147	70.724037
83	83.205780	71.765711	71.209526
84	84.052500	72.276283	71.709718

Table 24

Means, Standard Deviations, and Linear Equatings
for NO and CS from the IOT&E of the ASVAB 15/16/17
and the OPCAL of the ASVAB 18/19

NO Form	N	Mean	Standard Deviation	Linear Equating
15a	14,963	38.8567	8.9045	.9641 x + 2.1129
15b	14,399	39.1890	8.7044	.9862 x + .9240
15c	14,207	39.5732	8.5845	x
16a	14,287	40.5210	8.3005	1.0342 x - 2.3342
16b	13,822	39.5944	8.3949	1.0226 x - .9154
17a	13,571	39.7565	8.5045	1.0094 x - .5572
17b	13,010	39.6275	8.4828	1.0120 x - .5294
18a/b	5,206	39.3759	7.9059	.9614 x + 3.5372
18c	2,587	41.3927	7.6007	x
19a/b	5,130	39.4454	7.9851	.9519 x + 3.8464

CS Form	N	Mean	Standard Deviation	Linear Equating
15a/b	29,362	50.9602	13.1928	.9921 x - .1618
15c	14,207	50.3974	13.0890	x
16a/b	28,109	50.7056	12.8907	1.0154 x - 1.0882
17a/b	26,581	51.2578	12.9073	1.0141 x - 1.5820
18a/b	5,206	52.5386	12.4711	1.0108 x - .0134
18c	2,587	53.0932	12.6059	x
19a/b	5,130	52.8437	12.7300	.9903 x + .7644

Table 25

Conversion Table for the ASVAB 15f
Circular-Response Answer Sheet

For Test Scores GS, AR, WK, PC, NO, CS

RAW	GS	AR	WK	PC	NO	CS	RAW
0	20	26	21	20	20	22	0
1	20	26	22	20	20	22	1
2	22	27	23	20	20	23	2
3	24	28	24	23	21	24	3
4	26	30	25	26	22	24	4
5	28	31	26	29	23	25	5
6	30	33	28	32	24	26	6
7	32	34	29	35	25	26	7
8	34	35	30	38	26	27	8
9	36	37	31	41	27	28	9
10	38	38	32	44	28	28	10
11	40	40	33	47	29	29	11
12	42	41	34	51	30	30	12
13	44	42	36	54	31	30	13
14	46	44	37	57	32	31	14
15	47	45	38	60	33	31	15
16	49	47	39		34	32	16
17	51	48	40		35	33	17
18	53	49	41		35	33	18
19	55	51	42		36	34	19
20	57	52	44		37	34	20
21	59	54	45		38	35	21
22	61	55	46		39	35	22
23	63	56	47		40	36	23
24	65	58	48		41	36	24
25	67	59	49		42	37	25
26		61	50		43	38	26
27		62	52		44	38	27
28		63	53		45	39	28
29		65	54		46	39	29
30		66	55		47	40	30
31			56		48	40	31
32			57		49	41	32
33			58		50	42	33
34			60		51	42	34
35			61		52	43	35
36					53	43	36
37					55	44	37
38					56	45	38
39					57	45	39
40					57	46	40
41					58	47	41
42					59	47	42
43					59	48	43
44					60	48	44

RAW	GS	AR	WK	PC	NO	CS	RAW
45					60	49	45
46					61	50	46
47					61	50	47
48					61	51	48
49					62	51	49
50					62	52	50
51						53	51
52						53	52
53						54	53
54						54	54
55						55	55
56						56	56
57						56	57
58						57	58
59						58	59
60						58	60
61						59	61
62						60	62
63						60	63
64						61	64
65						61	65
66						62	66
67						63	67
68						63	68
69						64	69
70						64	70
71						65	71
72						65	72
73						66	73
74						66	74
75						67	75
76						67	76
77						68	77
76						68	78
79						69	79
80						69	80
81						70	81
82						70	82
83						71	83
84						71	84

continued

Table 25
(continued)

Conversion Table for the ASVAB 15f
Circular-Response Answer Sheet

For Test Scores AS, MK, MC, EI, VE

RAW	AS	MK	MC	EI	VE	RAW	RAW	AS	MK	MC	EI	VE	RAW
0	25	29	24	23	20	0	25	69	68	70		39	25
1	27	30	26	23	20	1	26					40	26
2	29	31	27	26	20	2	27					41	27
3	31	33	29	28	21	3	28					42	28
4	32	34	31	31	21	4	29					43	29
5	34	36	32	33	22	5	30					44	30
6	36	38	34	36	23	6	31					45	31
7	38	39	36	38	24	7	32					45	32
8	39	41	37	41	25	8	33					46	33
9	41	42	39	43	26	9	34					47	34
10	43	44	41	46	27	10	35					48	35
11	45	46	43	48	27	11	36					49	36
12	46	47	44	51	28	12	37					50	37
13	48	49	46	53	29	13	38					50	38
14	50	50	48	56	30	14	39					51	39
15	52	52	50	59	31	15	40					52	40
16	53	53	52	61	32	16	41					53	41
17	55	55	54	64	33	17	42					54	42
18	57	57	56	66	33	18	43					55	43
19	59	58	58	69	34	19	44					56	44
20	61	60	60	70	35	20	45					56	45
21	62	61	62		36	21	46					57	46
22	64	63	65		37	22	47					58	47
23	66	65	67		38	23	48					59	48
24	68	66	69		39	24	49					60	49
							50					61	50

Table 26

Conversion Table for the ASVAB 15g
Circular-Response Answer Sheet

For Test Scores GS, AR, WK, PC, NO, CS

RAW	GS	AR	WK	PC	NO	CS	RAW
0	20	26	20	20	20	22	0
1	20	26	20	20	20	22	1
2	22	27	20	21	20	23	2
3	24	28	22	24	20	24	3
4	26	30	23	27	21	24	4
5	28	31	24	30	22	25	5
6	30	33	25	33	23	26	6
7	32	34	27	36	24	26	7
8	34	35	28	39	25	27	8
9	36	37	29	42	26	28	9
10	38	38	30	45	27	28	10
11	40	40	32	48	28	29	11
12	42	41	33	51	29	30	12
13	44	42	34	54	30	30	13
14	46	44	35	57	31	31	14
15	47	45	37	60	32	31	15
16	49	46	38		33	32	16
17	51	48	39		34	33	17
18	53	49	40		35	33	18
19	55	51	42		35	34	19
20	57	52	43		36	34	20
21	59	53	44		37	35	21
22	61	55	45		38	35	22
23	63	56	47		39	36	23
24	65	58	48		40	36	24
25	67	59	49		41	37	25
26		60	50		43	38	26
27		62	52		44	38	27
28		63	53		45	39	28
29		64	54		46	39	29
30		66	55		47	40	30
31			57		48	40	31
32			58		49	41	32
33			59		50	42	33
34			60		51	42	34
35			61		52	43	35
36					53	43	36
37					54	44	37
38					55	45	38
39					56	45	39
40					57	46	40
41					58	47	41
42					59	47	42
43					59	48	43
44					60	48	44

RAW	GS	AR	WK	PC	NO	CS	RAW
45					60	49	45
46					61	50	46
47					61	50	47
48					61	51	48
49					62	51	49
50					62	52	50
51						53	51
52						53	52
53						54	53
54						54	54
55						55	55
56						56	56
57						56	57
58						57	58
59						58	59
60						58	60
61						59	61
62						60	62
63						60	63
64						61	64
65						61	65
66						62	66
67						63	67
68						63	68
69						64	69
70						64	70
71						65	71
72						65	72
73						66	73
74						66	74
75						67	75
76						67	76
77						68	77
78						68	78
79						69	79
80						69	80
81						70	81
82						70	82
83						71	83
84						71	84

continued

Table 26
(continued)

Conversion Table for the ASVAB 15g
Circular-Response Answer Sheet

For Test Scores AS, MK, MC, EI, VE

RAW	AS	MK	MC	EI	VE	RAW	RAW	AS	MK	MC	EI	VE	RAW
0	25	29	24	23	20	0	25	69	68	70		39	25
1	27	30	26	23	20	1	26					40	26
2	29	31	27	26	20	2	27					41	27
3	31	33	29	28	20	3	28					41	28
4	32	34	31	31	20	4	29					42	29
5	34	36	32	33	21	5	30					43	30
6	36	38	34	36	22	6	31					44	31
7	38	39	36	38	22	7	32					45	32
8	39	41	37	41	23	8	33					46	33
9	41	42	39	43	24	9	34					47	34
10	43	44	41	46	25	10	35					48	35
11	45	46	43	48	26	11	36					49	36
12	46	47	44	51	27	12	37					50	37
13	48	49	46	53	28	13	38					50	38
14	50	50	48	56	29	14	39					51	39
15	52	52	50	59	30	15	40					52	40
16	53	53	52	61	31	16	41					53	41
17	55	55	54	64	31	17	42					54	42
18	57	57	56	66	32	18	43					55	43
19	59	58	58	69	33	19	44					56	44
20	61	60	60	70	34	20	45					57	45
21	62	61	62		35	21	46					58	46
22	64	63	65		36	22	47					59	47
23	66	65	67		37	23	48					60	48
24	68	66	69		38	24	49					60	49
							50					61	50

Table 27

Conversion Table for the ASVAB 16f
Circular-Response Answer Sheet

For Test Scores GS, AR, WK, PC, NO, CS

RAW	GS	AR	WK	PC	NO	CS	RAW
0	20	26	20	20	20	21	0
1	22	26	20	20	20	22	1
2	24	26	20	22	20	22	2
3	26	27	21	25	20	23	3
4	28	29	22	28	20	24	4
5	29	30	23	31	20	24	5
6	31	32	25	34	20	25	6
7	33	33	26	36	21	26	7
8	35	35	27	39	22	26	8
9	37	36	28	42	23	27	9
10	39	38	30	45	24	28	10
11	41	39	31	48	26	28	11
12	42	40	32	51	27	29	12
13	44	42	33	53	28	30	13
14	46	43	35	56	29	30	14
15	48	45	36	59	30	31	15
16	50	46	37		31	32	16
17	52	48	39		32	32	17
18	54	49	40		33	33	18
19	55	51	41		33	34	19
20	57	52	42		34	34	20
21	59	54	44		35	35	21
22	61	55	45		36	35	22
23	63	56	46		37	36	23
24	65	58	47		38	36	24
25	67	59	49		40	37	25
26		61	50		41	37	26
27		62	51		42	38	27
28		64	53		43	38	28
29		65	54		44	39	29
30		66	55		46	40	30
31			56		47	40	31
32			58		48	41	32
33			59		49	41	33
34			60		50	42	34
35			61		51	43	35
36					52	43	46
37					53	44	37
38					54	45	38
39					55	45	39
40					56	46	40
41					57	47	41
42					58	47	42
43					58	48	43
44					59	48	44

RAW	GS	AR	WK	PC	NO	CS	RAW
45					59	49	45
46					60	50	46
47					60	50	47
48					60	51	48
49					61	52	49
50					61	52	50
51						53	51
52						53	52
53						54	53
54						55	54
55						55	55
56						56	56
57						57	57
58						57	58
59						58	59
60						59	60
61						59	61
62						60	62
63						61	63
64						61	64
65						62	65
66						62	66
67						63	67
68						64	68
69						64	69
70						65	70
71						65	71
72						66	72
73						66	73
74						67	74
75						67	75
76						68	76
77						68	77
78						69	78
79						69	79
80						70	80
81						70	81
82						71	82
83						71	83
84						72	84

continued

Table 27
(continued)

Conversion Table for the ASVAB 16f
Circular-Response Answer Sheet

For Test Scores AS, MK, MC, EI, VE

RAW	AS	MK	MC	EI	VE	RAW	RAW	AS	MK	MC	EI	VE	RAW
0	29	29	24	23	20	0	25	68	67	70		38	25
1	31	30	25	25	20	1	26					39	26
2	32	32	27	27	20	2	27					40	27
3	34	33	28	29	20	3	28					41	28
4	35	35	30	32	20	4	29					42	29
5	37	37	32	34	20	5	30					43	30
6	38	38	33	36	21	6	31					44	31
7	40	40	35	39	22	7	32					45	32
8	41	41	37	41	23	8	33					46	33
9	43	43	39	43	24	9	34					47	34
10	45	44	40	45	25	10	35					48	35
11	46	46	42	48	26	11	36					48	36
12	48	47	44	50	27	12	37					49	37
13	49	49	46	52	28	13	38					50	38
14	51	50	48	55	28	14	39					51	39
15	52	52	50	57	29	15	40					52	40
16	54	54	52	59	30	16	41					53	41
17	55	55	54	61	31	17	42					54	42
18	57	57	56	64	32	18	43					55	43
19	58	58	58	66	33	19	44					56	44
20	60	60	60	68	34	20	45					57	45
21	62	61	62		35	21	46					57	46
22	63	63	64		36	22	47					58	47
23	65	64	67		37	23	48					59	48
24	66	66	69		38	24	49					60	49
							50					61	50

Table 28

Conversion Table for the ASVAB 16g
Circular-Response Answer Sheet

For Test Scores GS, AR, WK, PC, NO, CS

RAW	GS	AR	WK	PC	NO	CS	RAW
0	20	26	20	20	20	21	0
1	22	26	20	20	20	22	1
2	24	28	20	21	20	22	2
3	26	29	20	24	20	23	3
4	28	30	21	27	20	24	4
5	29	32	22	30	20	24	5
6	31	33	23	33	21	25	6
7	33	35	25	36	22	26	7
8	35	36	26	39	23	26	8
9	37	37	27	42	25	27	9
10	39	39	29	45	26	28	10
11	41	40	30	48	27	28	11
12	42	41	31	51	28	29	12
13	44	43	33	54	29	30	13
14	46	44	34	57	30	30	14
15	48	45	35	60	31	31	15
16	50	47	36		32	32	16
17	52	48	38		33	32	17
18	54	49	39		34	33	18
19	55	51	40		34	34	19
20	57	52	42		35	34	20
21	59	54	43		36	35	21
22	61	55	44		37	35	22
23	63	56	46		38	36	23
24	65	58	47		39	36	24
25	67	59	48		41	37	25
26		60	50		42	37	26
27		62	51		43	38	27
28		63	52		44	38	28
29		64	54		45	39	29
30		66	55		46	40	30
31			56		48	40	31
32			58		49	41	32
33			59		50	41	33
34			60		51	42	34
35			61		52	43	35
36					53	43	36
37					54	44	37
38					55	45	38
39					56	45	39
40					57	46	40
41					58	47	41
42					59	47	42
43					59	48	43
44					60	48	44

RAW	GS	AR	WK	PC	NO	CS	RAW
45					60	49	45
46					60	50	46
47					61	50	47
48					61	51	48
49					62	52	49
50					62	52	50
51						53	51
52						53	52
53						54	53
54						55	54
55						55	55
56						56	56
57						57	57
58						57	58
59						58	59
60						59	60
61						59	61
62						60	62
63						61	63
64						61	64
65						62	65
66						62	66
67						63	67
68						64	68
69						64	69
70						65	70
71						65	71
72						66	72
73						66	73
74						67	74
75						67	75
76						68	76
77						68	77
78						69	78
79						69	79
80						70	80
81						70	81
82						71	82
83						71	83
84						72	84

continued

Table 28
(continued)

Conversion Table for the ASVAB 16g
Circular-Response Answer Sheet

For Test Scores AS, MK, MC, EI, VE

RAW	AS	MK	MC	EI	VE	RAW	RAW	AS	MK	MC	EI	VE	RAW
0	29	29	24	23	20	0	25	68	67	70		38	25
1	31	30	25	25	20	1	26					39	26
2	32	32	27	27	20	2	27					40	27
3	34	33	28	29	20	3	28					41	28
4	35	35	30	32	20	4	29					42	29
5	37	37	32	34	20	5	30					43	30
6	38	38	33	36	20	6	31					44	31
7	40	40	35	39	21	7	32					44	32
8	41	41	37	41	22	8	33					45	33
9	43	43	39	43	23	9	34					46	34
10	45	44	40	45	24	10	35					47	35
11	46	46	42	48	25	11	36					48	36
12	48	47	44	50	26	12	37					49	37
13	49	49	46	52	26	13	38					50	38
14	51	50	48	55	27	14	39					51	39
15	52	52	50	57	28	15	40					52	40
16	54	54	52	59	29	16	41					53	41
17	55	55	54	61	30	17	42					54	42
18	57	57	56	64	31	18	43					55	43
19	58	58	58	66	32	19	44					56	44
20	60	60	60	68	33	20	45					57	45
21	62	61	62		34	21	46					58	46
22	63	63	64		35	22	47					59	47
23	65	64	67		36	23	48					60	48
24	66	66	69		37	24	49					61	49
							50					62	50

Table 29

Conversion Table for the ASVAB 17f
Circular-Response Answer Sheet

For Test Scores GS, AR, WK, PC, NO, CS

RAW	GS	AR	WK	PC	NO	CS	RAW
0	20	26	20	20	20	21	0
1	21	27	21	20	20	21	1
2	23	28	22	22	20	22	2
3	25	30	23	25	20	23	3
4	27	31	24	28	20	23	4
5	28	32	25	31	20	24	5
6	30	34	27	34	22	25	6
7	32	35	28	37	23	25	7
8	34	36	29	40	24	26	8
9	36	38	30	42	25	27	9
10	38	39	31	45	26	27	10
11	40	40	33	48	27	28	11
12	42	42	34	51	28	29	12
13	44	43	35	54	29	30	13
14	46	44	36	57	30	30	14
15	48	46	37	60	31	31	15
16	50	47	38		32	32	16
17	52	48	40		33	32	17
18	54	50	41		34	33	18
19	56	51	42		34	33	19
20	58	52	43		35	34	20
21	60	53	44		36	34	21
22	62	55	45		37	35	22
23	64	56	47		38	35	23
24	65	57	48		39	36	24
25	67	59	49		41	36	25
26		60	50		42	37	26
27		61	51		43	38	27
28		63	53		44	38	28
29		64	54		45	39	29
30		65	55		46	39	30
31			56		47	40	31
32			57		48	41	32
33			58		50	41	33
34			60		51	42	34
35			61		52	42	35
36					53	43	36
37					54	44	37
38					55	44	38
39					56	45	39
40					57	46	40
41					58	46	41
42					58	47	42
43					59	47	43
44					59	48	44
45					60	49	45
46					60	49	46
47					61	50	47
48					61	51	48
49					61	51	49
50					62	52	50
51						52	51
52						53	52
53						54	53
54						54	54
55						55	55
56						56	56
57						56	57
58						57	58
59						58	59
60						58	60
61						59	61
62						60	62
63						60	63
64						61	64
65						61	65
66						62	66
67						63	67
68						63	68
69						64	69
70						64	70
71						65	71
72						66	72
73						66	73
74						67	74
75						67	75
76						68	76
77						68	77
78						69	78
79						69	79
80						70	80
81						70	81
82						70	82
83						71	83
84						72	84

continued

Table 29
(continued)

Conversion Table for the ASVAB 17f
Circular-Response Answer Sheet

For Test Scores AS, MK, MC, EI, VE

RAW	AS	MK	MC	EI	VE	RAW	RAW	AS	MK	MC	EI	VE	RAW
0	26	29	25	23	20	0	25	68	68	70		39	25
1	28	29	26	26	20	1	26					40	26
2	29	30	27	28	20	2	27					41	27
3	31	32	29	30	20	3	28					42	28
4	33	34	30	32	21	4	29					43	29
5	34	35	31	35	22	5	30					44	30
6	36	37	33	37	23	6	31					44	31
7	38	39	35	39	24	7	32					45	32
8	39	40	36	41	25	8	33					46	33
9	41	42	38	44	25	9	34					47	34
10	43	44	40	46	26	10	35					48	35
11	45	45	42	48	27	11	36					49	36
12	46	47	44	50	28	12	37					50	37
13	48	49	46	53	29	13	38					50	38
14	50	50	48	55	30	14	39					51	39
15	51	52	50	57	31	15	40					52	40
16	53	54	52	60	31	16	41					53	41
17	55	55	54	62	32	17	42					54	42
18	56	57	56	64	33	18	43					55	43
19	58	58	58	66	34	19	44					56	44
20	60	60	60	69	35	20	45					57	45
21	61	62	63		36	21	46					57	46
22	63	63	65		37	22	47					58	47
23	65	65	67		37	23	48					59	48
24	66	67	69		38	24	49					60	49
							50					61	50

Table 30

Conversion Table for the ASVAB 17g
Circular-Response Answer Sheet

For Test Scores GS, AR, WK, PC, NO, CS

RAW	GS	AR	WK	PC	NO	CS	RAW
0	20	26	20	20	20	21	0
1	21	26	20	20	20	21	1
2	23	28	20	20	20	22	2
3	25	29	22	23	20	23	3
4	27	31	23	26	20	23	4
5	28	32	24	30	21	24	5
6	30	33	25	33	22	25	6
7	32	35	27	36	23	25	7
8	34	36	28	39	24	26	8
9	36	37	29	42	25	27	9
10	38	39	30	45	26	27	10
11	40	40	32	48	27	28	11
12	42	42	33	51	28	29	12
13	44	43	34	54	29	30	13
14	46	44	35	58	30	30	14
15	48	46	36	61	31	31	15
16	50	47	38		32	32	16
17	52	49	39		33	32	17
18	54	50	40		34	33	18
19	56	51	41		35	33	19
20	58	53	43		35	34	20
21	60	54	44		36	34	21
22	62	55	45		37	35	22
23	64	57	46		38	35	23
24	65	58	47		39	36	24
25	67	59	49		41	36	25
26		61	50		42	37	26
27		62	51		43	38	27
28		63	52		44	38	28
29		65	54		45	39	29
30		66	55		47	39	30
31			56		48	40	31
32			57		49	41	32
33			58		50	41	33
34			60		51	42	34
35			61		52	42	35
36					53	43	36
37					54	44	37
38					55	44	38
39					56	45	39
40					57	46	40
41					58	46	41
42					59	47	42
43					59	47	43
44					60	48	44

RAW	GS	AR	WK	PC	NO	CS	RAW
45					60	49	45
46					60	49	46
47					61	50	47
48					61	51	48
49					62	51	49
50					62	52	50
51						52	51
52						53	52
53						54	53
54						54	54
55						55	55
56						56	56
57						56	57
58						57	58
59						58	59
60						58	60
61						59	61
62						60	62
63						60	63
64						61	64
65						61	65
66						62	66
67						63	67
68						63	68
69						64	69
70						64	70
71						65	71
72						66	72
73						66	73
74						67	74
75						67	75
76						68	76
77						68	77
78						69	78
79						69	79
80						70	80
81						70	81
82						70	82
83						71	83
84						72	84

continued

Table 30
(continued)

Conversion Table for the ASVAB 17g
Circular-Response Answer Sheet

For Test Scores AS, MK, MC, EI, VE

RAW	AS	MK	MC	EI	VE	RAW	RAW	AS	MK	MC	EI	VE	RAW
0	26	29	25	23	20	0	25	68	68	70		38	25
1	28	29	26	26	20	1	26					39	26
2	29	30	27	28	20	2	27					40	27
3	31	32	29	30	20	3	28					41	28
4	33	34	30	32	20	4	29					42	29
5	34	35	31	35	20	5	30					43	30
6	36	37	33	37	21	6	31					44	31
7	38	39	35	39	22	7	32					45	32
8	39	40	36	41	23	8	33					46	33
9	41	42	38	44	24	9	34					47	34
10	43	44	40	46	25	10	35					48	35
11	45	45	42	48	26	11	36					49	36
12	46	47	44	50	27	12	37					49	37
13	48	49	46	53	28	13	38					50	38
14	50	50	48	55	28	14	39					51	39
15	51	52	50	57	29	15	40					52	40
16	53	54	52	60	30	16	41					53	41
17	55	55	54	62	31	17	42					54	42
18	56	57	56	64	32	18	43					55	43
19	58	58	58	66	33	19	44					56	44
20	60	60	60	69	34	20	45					57	45
21	61	62	63		35	21	46					58	46
22	63	63	65		36	22	47					59	47
23	65	65	67		37	23	48					59	48
24	66	67	69		38	24	49					60	49
							50					61	50

Table 31

Conversion Table for the ASVAB 18f
Circular-Response Answer Sheet

For Test Scores GS, AR, WK, PC, NO, CS

RAW	GS	AR	WK	PC	NO	CS	RAW
0	20	26	20	24	20	22	0
1	20	26	20	26	20	22	1
2	22	26	20	29	21	23	2
3	24	28	21	31	22	24	3
4	26	29	22	34	23	24	4
5	28	30	24	36	24	25	5
6	30	32	25	38	25	26	6
7	32	33	26	41	26	26	7
8	34	35	27	43	27	27	8
9	36	36	29	46	28	28	9
10	38	38	30	48	29	28	10
11	40	39	31	51	30	29	11
12	42	40	32	53	31	30	12
13	44	42	34	56	32	30	13
14	46	43	35	58	33	31	14
15	47	45	36	61	34	32	15
16	49	46	37		35	32	16
17	51	47	38		36	33	17
18	53	49	40		37	34	18
19	55	50	41		37	34	19
20	57	52	42		38	35	20
21	59	53	43		39	35	21
22	61	55	45		40	36	22
23	63	56	46		41	36	23
24	65	57	47		42	37	24
25	67	59	48		43	37	25
26		60	49		44	38	26
27		62	51		46	38	27
28		63	52		47	39	28
29		64	53		48	40	29
30		66	54		49	40	30
31			56		50	41	31
32			57		51	41	32
33			58		52	42	33
34			59		53	43	34
35			61		54	43	35
36					55	44	36
37					56	45	37
38					57	45	38
39					58	46	39
40					59	46	40
41					59	47	41
42					60	48	42
43					61	48	43
44					61	49	44

RAW	GS	AR	WK	PC	NO	CS	RAW
45					61	50	45
46					62	50	46
47					62	51	47
48					63	51	48
49					63	52	49
50					63	53	50
51						53	51
52						54	52
53						55	53
54						55	54
55						56	55
56						56	56
57						57	57
58						58	58
59						58	59
60						59	60
61						60	61
62						60	62
63						61	63
64						62	64
65						62	65
66						63	66
67						63	67
68						64	68
69						65	69
70						65	70
71						66	71
72						66	72
73						67	73
74						67	74
75						68	75
76						68	76
77						69	77
78						69	78
79						70	79
80						70	80
81						71	81
82						71	82
83						72	83
84						72	84

continued

Table 31
(continued)

Conversion Table for the ASVAB 18f
Circular-Response Answer Sheet

For Test Scores AS, MK, MC, EI, VE

RAW	AS	MK	MC	EI	VE	RAW
0	26	30	24	23	20	0
1	28	31	24	25	20	1
2	29	33	26	28	21	2
3	31	34	28	30	22	3
4	33	36	29	32	23	4
5	35	37	31	35	23	5
6	36	39	33	37	24	6
7	38	40	35	39	25	7
8	40	42	37	42	26	8
9	41	43	38	44	27	9
10	43	45	40	47	28	10
11	45	46	42	49	28	11
12	47	48	44	51	29	12
13	48	49	46	54	30	13
14	50	51	48	56	31	14
15	52	52	50	58	32	15
16	53	54	52	60	33	16
17	55	55	54	63	33	17
18	57	57	56	65	34	18
19	58	58	58	67	35	19
20	60	60	60	70	36	20
21	62	61	62		37	21
22	64	63	65		38	22
23	65	64	67		38	23
24	67	66	69		39	24

RAW	AS	MK	MC	EI	VE	RAW
25	69	67	70		40	25
26					41	26
27					42	27
28					43	28
29					43	29
30					44	30
31					45	31
32					46	32
33					47	33
34					48	34
35					48	35
36					49	36
37					50	37
38					51	38
39					52	39
40					52	40
41					53	41
42					54	42
43					55	43
44					56	44
45					57	45
46					57	46
47					58	47
48					59	48
49					60	49
50					61	50

Table 32

Conversion Table for the ASVAB 18g
Circular-Response Answer Sheet

For Test Scores GS, AR, WK, PC, NO, CS

RAW	GS	AR	WK	PC	NO	CS	RAW
0	20	26	20	20	20	22	0
1	20	26	20	23	20	22	1
2	22	27	20	25	21	23	2
3	24	29	20	28	22	24	3
4	26	30	21	31	23	24	4
5	28	31	22	33	24	25	5
6	30	33	23	36	25	26	6
7	32	34	25	39	26	26	7
8	34	35	26	42	27	27	8
9	36	36	27	44	28	28	9
10	38	38	28	47	29	28	10
11	40	39	30	50	30	29	11
12	42	40	31	53	31	30	12
13	44	41	32	55	32	30	13
14	46	43	34	58	33	31	14
15	47	44	35	61	34	32	15
16	49	46	36		35	32	16
17	51	47	38		36	33	17
18	53	48	39		37	34	18
19	55	50	40		37	34	19
20	57	51	41		38	35	20
21	59	53	43		39	35	21
22	61	54	44		40	36	22
23	63	56	45		41	36	23
24	65	57	47		42	37	24
25	67	59	48		43	37	25
26		61	49		44	38	26
27		62	51		46	38	27
28		64	52		47	39	28
29		65	53		48	40	29
30		66	55		49	40	30
31			56		50	41	31
32			57		51	41	32
33			58		52	42	33
34			60		53	43	34
35			61		54	43	35
36					55	44	36
37					56	45	37
38					57	45	38
39					58	46	39
40					59	46	40
41					59	47	41
42					60	48	42
43					61	48	43
44					61	49	44

RAW	GS	AR	WK	PC	NO	CS	RAW
45					61	50	45
46					62	50	46
47					62	51	47
48					63	51	48
49					63	52	49
50					63	53	50
51						53	51
52						54	52
53						55	53
54						55	54
55						56	55
56						56	56
57						57	57
58						58	58
59						58	59
60						59	60
61						60	61
62						60	62
63						61	63
64						62	64
65						62	65
66						63	66
67						63	67
68						64	68
69						65	69
70						65	70
71						66	71
72						66	72
73						67	73
74						67	74
75						68	75
76						68	76
77						69	77
78						69	78
79						70	79
80						70	80
81						71	81
82						71	82
83						72	83
84						72	84

continued

Table 32
(continued)

Conversion Table for the ASVAB 18g
Circular-Response Answer Sheet

For Test Scores AS, MK, MC, EI, VE

RAW	AS	MK	MC	EI	VE	RAW	RAW	AS	MK	MC	EI	VE	RAW
0	26	29	24	23	20	0	25	69	67	70		39	25
1	28	30	24	25	20	1	26					40	26
2	29	31	26	28	20	2	27					41	27
3	31	33	28	30	20	3	28					42	28
4	33	35	29	32	20	4	29					42	29
5	35	36	31	35	21	5	30					43	30
6	36	38	33	37	22	6	31					44	31
7	38	39	35	39	23	7	32					45	32
8	40	41	37	42	24	8	33					46	33
9	41	42	38	44	25	9	34					47	34
10	43	44	40	47	26	10	35					48	35
11	45	45	42	49	26	11	36					49	36
12	47	47	44	51	27	12	37					50	37
13	48	49	46	54	28	13	38					50	38
14	50	50	48	56	29	14	39					51	39
15	52	52	50	58	30	15	40					52	40
16	53	53	52	60	31	16	41					53	41
17	55	55	54	63	32	17	42					54	42
18	57	56	56	65	33	18	43					55	43
19	58	58	58	67	34	19	44					56	44
20	60	59	60	70	34	20	45					57	45
21	62	61	62		35	21	46					58	46
22	64	62	65		36	22	47					58	47
23	65	64	67		37	23	48					59	48
24	67	66	69		38	24	49					60	49
							50					61	50

Table 33

Conversion Table for the ASVAB 19f
Circular-Response Answer Sheet

For Test Scores GS, AR, WK, PC, NO, CS

RAW	GS	AR	WK	PC	NO	CS	RAW
0	20	26	20	24	20	22	0
1	20	26	20	26	20	23	1
2	21	26	20	29	21	23	2
3	23	28	21	31	22	24	3
4	25	29	22	34	23	25	4
5	27	30	24	36	24	25	5
6	29	32	25	38	25	26	6
7	31	33	26	41	26	27	7
8	33	35	27	43	27	27	8
9	35	36	29	46	28	28	9
10	37	38	30	48	29	29	10
11	40	39	31	51	30	29	11
12	42	40	32	53	31	30	12
13	44	42	34	56	32	31	13
14	46	43	35	58	33	31	14
15	48	45	36	61	34	32	15
16	50	46	37		35	33	16
17	52	47	38		36	33	17
18	54	49	40		37	34	18
19	56	50	41		37	34	19
20	59	52	42		38	35	20
21	61	53	43		39	35	21
22	63	55	45		40	36	22
23	65	56	46		41	36	23
24	67	57	47		42	37	24
25	68	59	48		43	37	25
26		60	49		44	38	26
27		62	51		46	39	27
28		63	52		47	39	28
29		64	53		48	40	29
30		66	54		49	40	30
31			56		50	41	31
32			57		51	41	32
33			58		52	42	33
34			59		53	43	34
35			61		54	43	35
36					55	44	36
37					56	45	37
38					57	45	38
39					58	46	39
40					59	46	40
41					59	47	41
42					60	48	42
43					61	48	43
44					61	49	44

RAW	GS	AR	WK	PC	NO	CS	RAW
45					61	49	45
46					62	50	46
47					62	51	47
48					62	51	48
49					63	52	49
50					63	52	50
51						53	51
52						54	52
53						54	53
54						55	54
55						56	55
56						56	56
57						57	57
58						57	58
59						58	59
60						59	60
61						59	61
62						60	62
63						61	63
64						61	64
65						62	65
66						62	66
67						63	67
68						64	68
69						64	69
70						65	70
71						65	71
72						66	72
73						66	73
74						67	74
75						67	75
76						68	76
77						68	77
78						69	78
79						69	79
80						70	80
81						70	81
82						71	82
83						71	83
84						72	84

continued

Table 33
(continued)

Conversion Table for the ASVAB 19f
Circular-Response Answer Sheet

For Test Scores AS, MK, MC, EI, VE

RAW	AS	MK	MC	EI	VE	RAW	RAW	AS	MK	MC	EI	VE	RAW
0	24	30	24	23	20	0	25	68	67	70		40	25
1	25	31	24	25	20	1	26					41	26
2	27	33	26	28	21	2	27					42	27
3	29	34	28	30	22	3	28					43	28
4	31	36	30	32	23	4	29					43	29
5	33	37	32	35	23	5	30					44	30
6	35	39	34	37	24	6	31					45	31
7	36	40	36	39	25	7	32					46	32
8	38	42	38	42	26	8	33					47	33
9	40	43	40	44	27	9	34					48	34
10	42	45	42	46	28	10	35					48	35
11	44	46	43	49	28	11	36					49	36
12	46	48	45	52	29	12	37					50	37
13	47	49	47	54	30	13	38					51	38
14	49	51	49	57	31	14	39					52	39
15	51	52	51	59	32	15	40					52	40
16	53	54	53	61	33	16	41					53	41
17	55	55	55	63	33	17	42					54	42
18	56	57	57	65	34	18	43					55	43
19	58	58	59	67	35	19	44					56	44
20	60	60	61	68	36	20	45					57	45
21	62	61	63		37	21	46					57	46
22	63	63	64		38	22	47					58	47
23	65	64	66		38	23	48					59	48
24	67	66	68		39	24	49					60	49
							50					61	50

Table 34

Conversion Table for the ASVAB 19g
Circular-Response Answer Sheet

For Test Scores GS, AR, WK, PC, NO, CS

RAW	GS	AR	WK	PC	NO	CS	RAW
0	20	26	20	20	20	22	0
1	20	26	20	23	20	23	1
2	21	27	20	25	21	23	2
3	23	29	20	28	22	24	3
4	25	30	21	31	23	25	4
5	27	31	22	33	24	25	5
6	29	33	23	36	25	26	6
7	31	34	25	39	26	27	7
8	33	35	26	42	27	27	8
9	35	36	27	44	28	28	9
10	37	38	28	47	29	29	10
11	40	39	30	50	30	29	11
12	42	40	31	53	31	30	12
13	44	41	32	55	32	31	13
14	46	43	34	58	33	31	14
15	48	44	35	61	34	32	15
16	50	46	36		35	33	16
17	52	47	38		36	33	17
18	54	48	39		37	34	18
19	56	50	40		37	34	19
20	59	51	41		38	35	20
21	61	53	43		39	35	21
22	63	54	44		40	36	22
23	65	56	45		41	36	23
24	67	57	47		42	37	24
25	68	59	48		43	37	25
26		61	49		44	38	26
27		62	51		46	39	27
28		64	52		47	39	28
29		65	53		48	40	29
30		66	55		49	40	30
31			56		50	41	31
32			57		51	41	32
33			58		52	42	33
34			60		53	43	34
35			61		54	43	35
36					55	44	36
37					56	45	37
38					57	45	38
39					58	46	39
40					59	46	40
41					59	47	41
42					60	48	42
43					61	48	43
44					61	49	44

RAW	GS	AR	WK	PC	NO	CS	RAW
45					61	49	45
46					62	50	46
47					62	51	47
48					62	51	48
49					63	52	49
50					63	52	50
51						53	51
52						54	52
53						54	53
54						55	54
55						56	55
56						56	56
57						57	57
58						57	58
59						58	59
60						59	60
61						59	61
62						60	62
63						61	63
64						61	64
65						62	65
66						62	66
67						63	67
68						64	68
69						64	69
70						65	70
71						65	71
72						66	72
73						66	73
74						67	74
75						67	75
76						68	76
77						68	77
78						69	78
79						69	79
80						70	80
81						70	81
82						71	82
83						71	83
84						72	84

continued

Table 34
(continued)

Conversion Table for the ASVAB 19g
Circular-Response Answer Sheet

For Test Scores AS, MK, MC, EI, VE

RAW	AS	MK	MC	EI	VE	RAW	RAW	AS	MK	MC	EI	VE	RAW
0	24	29	24	23	20	0	25	68	67	70		39	25
1	25	30	24	25	20	1	26					40	26
2	27	31	26	28	20	2	27					41	27
3	29	33	28	30	20	3	28					42	28
4	31	35	30	32	20	4	29					42	29
5	33	36	32	35	21	5	30					43	30
6	35	38	34	37	22	6	31					44	31
7	36	39	36	39	23	7	32					45	32
8	38	41	38	42	24	8	33					46	33
9	40	42	40	44	25	9	34					47	34
10	42	44	42	46	26	10	35					48	35
11	44	45	43	49	26	11	36					49	36
12	46	47	45	52	27	12	37					50	37
13	47	49	47	54	28	13	38					50	38
14	49	50	49	57	29	14	39					51	39
15	51	52	51	59	30	15	40					52	40
16	53	53	53	61	31	16	41					53	41
17	55	55	55	63	32	17	42					54	42
18	56	56	57	65	33	18	43					55	43
19	58	58	59	67	34	19	44					56	44
20	60	59	61	68	34	20	45					57	45
21	62	61	63		35	21	46					58	46
22	63	62	64		36	22	47					58	47
23	65	64	66		37	23	48					59	48
24	67	66	68		38	24	49					60	49
							50					61	50

Table 35

The ASVAB Test Composites
for the Enlistment Testing Program

Service	Composite	Definition
All	AFQT	2VE + AR + MK
Army	GT	VE + AR
	GM	MK + EI + AS + GS
	EL	AR + MK + EI + GS
	CL	AR + MK + VE
	MM	NO + AS + MC + EI
	SC	AR + AS + MC + VE
	CO	CS + AR + MC + AS
	FA	AR + CS + MC + MK
	OF	NO + AS + MC + VE
	ST	VE + MK + MC + GS
Navy	EL	AR + MK + EI + GS
	E	AR + GS + 2MK
	CL	NO + CS + VE
	GT	VE + AR
	ME	VE + MC + AS
	EG	MK + AS
	CT	VE + AR + NO + CS
	HM	VE + MK + GS
	ST	VE + AR + MC
	MR	AR + MC + AS
	BC	VE + MK + CS
Air Force	M	MC + GS + 2AS
	A	NO + CS + VE
	G	VE + AR
	E	AR + MK + EI + GS
Marine Corps	MM	AR + EI + MC + AS
	CL	VE + MK + CS
	GT	VE + AR + MC
	EL	AR + MK + EI + GS

Table 36

Tests and Upper Bounds of Categories for Composites

Composite		Category Upper Bounds
AFQT*	2VE + AR + MK	09/15/20/30/49/64/92/99
Army**		
GT	VE + AR	109/160
GM	MK + EI + AS + GS	84/89/94/99/104/160
EL	AR + MK + EI + GS	84/89/94/99/104/109/114/119/160
CL	AR + MK + VE	84/89/94/99/104/109/160
MM	NO + AS + MC + EI	89/94/99/104/160
SC	AR + AS + MC + VE	89/94/99/104/160
CO	CS + AR + MC + AS	84/89/94/99/160
FA	AR + CS + MC + MK	84/89/94/99/160
OF	NO + AS + MC + VE	89/94/99/104/160
ST	VE + MK + MC + GS	84/89/94/99/104/109/114/160
Navy***		
EL	AR + MK + EI + GS	189/199/203/217/320
E	AR + GS + 2MK	195/199/203/209/213/320
CL	NO + CS + VE	159/240
GT	VE + AR	88/95/96/102/107/112/114/160
ME	VE + MC + AS	149/157/166/240
EG	MK + AS	95/160
CT	VE + AR + NO + CS	201/320
HM	VE + MK + GS	148/164/240
ST	VE + AR + MC	146/240
MR	AR + MC + AS	129/157/163/240
BC	VE + MK + CS	146/152/240
Air Force*		
M	MC + GS + 2AS	43/44/50/56/60/88/99
A	NO + CS + VE	26/31/39/44/50/60/66/99
G	VE + AR	29/34/38/41/42/47/49/52/55/57/63/68/69/99
E	AR + MK + EI + GS	32/38/42/44/45/49/57/66/71/76/80/99
Marine Corps**		
MM	AR + EI + MC + AS	84/94/104/114/160
CL	VE + MK + CS	79/89/99/109/119/160
GT	VE + AR + MC	79/89/99/109/160
EL	AR + MK + EI + GS	89/99/109/114/160

* Percentile Scores
** Standard Scores (Mean=100, S.D.=20)
*** Sum of Test Standard Scores

Table 37

Answer Sheet by Composite Category
Chi-squares, Degrees of Freedom, and Probabilities

Composite	Chi-Square	Degrees of Freedom	Probability
AFQT	13.950	7	.052
Army			
GT	3.918	1	.048
GM	3.198	5	.669
EL	8.913	8	.350
CL	9.043	6	.171
MM*	3.569	4	.467
SC	5.161	4	.271
CO*	5.810	4	.214
FA*	4.551	4	.337
OF*	3.781	4	.436
ST	4.812	7	.683
Navy			
EL	6.834	4	.145
E	2.836	5	.725
CL*	0.051	1	.822
GT	7.239	7	.404
ME	9.022	3	.029
EG	0.531	1	.466
CT*	0.042	1	.837
HM	4.370	2	.112
ST	1.664	1	.197
MR	1.814	3	.612
BC*	5.215	2	.074
Air Force			
M	6.933	6	.327
A*	7.695	7	.360
G	17.474	12	.133
E	12.206	11	.348
Marine Corps			
MM	2.561	4	.634
CL*	4.886	5	.430
GT	2.790	4	.593
EL	3.053	4	.549

* Composite includes NO and/or CS.

Table 38

Percentage of Subjects Above Indicated AFQT Score, by Type of Answer Sheet

AFQT	(Cat.)	Vertical-Response Answer Sheet	r-Response Sheet	Difference*
> 09	(IVc)	99.77	99.93	-.16 +/- 0.19
> 15	(IVb)	99.01	98.70	.31 +/- 0.54
> 20	(IVa)	96.72	96.20	.52 +/- 0.94
> 30	(IIIb)	87.32	86.26	1.06 +/- 1.71
> 49	(IIIa)	59.02	57.53	1.49 +/- 2.48
> 64	(II)	35.58	32.72	2.86 +/- 2.39
> 92	(I)	2.99	3.29	-.38 +/- 0.87

* +/- 2 Standard Errors of the Difference

Table 39

Phase II Expected Number Right from Pure Guessing
and Percentage of Subjects with Scores Below this Level
by Test and Type of Answer Sheet

Test	Expected Number Right From Pure Guessing	Percentage At or Below Expectation	
		Student Answer Sheet	Enlistment Answer Sheet
GS	6.25	0.0	0.3
AR	7.50	0.9	0.6
WK	8.75	0.0	0.0
PC	3.75	1.7	0.8
NO	12.5	0.3	0.6
CS	16.8	0.6	0.6
AS	6.25	2.3	2.5
MK	6.25	2.3	4.2
MC	6.25	2.6	1.9
EI	5.00	2.6	3.3

Table 40

Phase II Distribution of Number of Tests
with Scores Below Pure-guessing Expectation,
by Type of Answer Sheet

Number of Test Scores Below Expectation	Student Answer Sheet Frequency	Student Answer Sheet Percentage	Enlistment Answer Sheet Frequency	Enlistment Answer Sheet Percentage
0	318	90.3	320	88.9
1	26	7.4	32	8.9
2	7	2.0	5	1.4
3	0	0.0	3	0.6
4	0	0.0	0	0.0
5	0	0.0	1	0.3
6	1	0.3	0	0.0
7	0	0.0	0	0.0
8	0	0.0	0	0.0
9	0	0.0	0	0.0
10	0	0.0	0	0.0
Totals	352		360	

Table 41

Phase II Gender and Ethnicity Information,
by Type of Answer Sheet

Classification	Student Answer Sheet Frequency	Student Answer Sheet Percentage	Enlistment Answer Sheet Frequency	Enlistment Answer Sheet Percentage
Gender				
Male	302	86.5	310	87.3
Female	47	13.5	45	12.7
Subtotal	349		355	
No Identifiable Response	2		2	
Ethnicity				
Caucasian	228	65.1	226	68.5
Non-Caucasian	122	34.9	104	31.5
Subtotal	351		330	
No Identifiable Response	1		27	
Totals	351		357	

Table 42

Phase II Percentage Matching SSNs, Pre-enlistment ASVAB Means, Variances, t-ratios, and Effect-size Estimates*

		Student Answer Sheet	Enlistment Answer Sheet	t-ratio	Effect Size**
N Total		3,162	3,158		
N Matched SSNs		3,104	3,142		
Percentage Matched		98.2	99.5		
GS	Mean	53.54	54.02	-.892	-.048
	Variance	50.678	50.695		
AR	Mean	53.36	53.69	-.610	-.033
	Variance	51.906	50.834		
NO	Mean	54.50	54.69	-.392	-.019
	Variance	42.749	39.478		
CS	Mean	52.98	53.38	-.715	-.040
	Variance	61.095	48.525		
AS	Mean	52.68	52.14	.811	.054
	Variance	75.957	79.811		
MK	Mean	55.53	55.45	.139	.008
	Variance	57.983	58.186		
MC	Mean	53.75	54.08	-.545	-.033
	Variance	66.274	62.388		
EI	Mean	52.42	52.32	.166	.010
	Variance	64.488	63.188		
VE	Mean	53.64	54.09	-1.246	.045
	Variance	21.235	24.561		
AFQT	Mean	61.16	63.36	-1.554	-.077
	Variance	337.680	366.198		

* Standard scores on tests; percentile on AFQT.
WK and PC tests not included in this analysis.
(See text for explanation)

** S.D. of tests = 10; S.D. of AFQT percentile = 28.6

Table 43

Phase II Test Means, Variances, Chi-squares, t-ratios, and Effect-size Estimates

Test**		Student Answer Sheet	Enlistment Answer Sheet	Chi-Square	t-ratio	Effect Size*
GS				1.861		
	Mean	17.322	17.471		.522	-.030
	Variance	13.648	15.132			(.018)
AR				2.853		
	Mean	19.162	19.409		.571	-.033
	Variance	35.039	30.900			(.000)
NO				1.549		
	Mean	41.105	40.353		-1.238	.070
	Variance	63.015	67.847			(.089)
CS				1.711		
	Mean	52.744	53.084		.325	-.020
	Variance	206.80	181.72			(.040)
AS				.491		
	Mean	15.715	15.740		.069	-.004
	Variance	21.524	22.794			(-.058)
MK				1.426		
	Mean	15.954	16.434		1.426	-.075
	Variance	28.924	28.685			(-.083)
MC				.391		
	Mean	15.413	15.633		.391	-.041
	Variance	22.203	21.946			(-.008)
EI				.332		
	Mean	12.254	12.336		.319	-.019
	Variance	12.156	11.550			(-.029)
VE				5.143		
	Mean	39.285	40.317		2.195	-.097
	Variance	40.342	37.835			(-.052)

* [Mean(Student) - Mean(Enlistment)] / S.D.(Normative)
Net effect size in parentheses: Effect size from this table, minus effect size from Table 42

** WK and PC tests not included in this analysis. (See text for explanation)

ASVAB OMR OPCAL SUPPLEMENT FIGURES 1-13

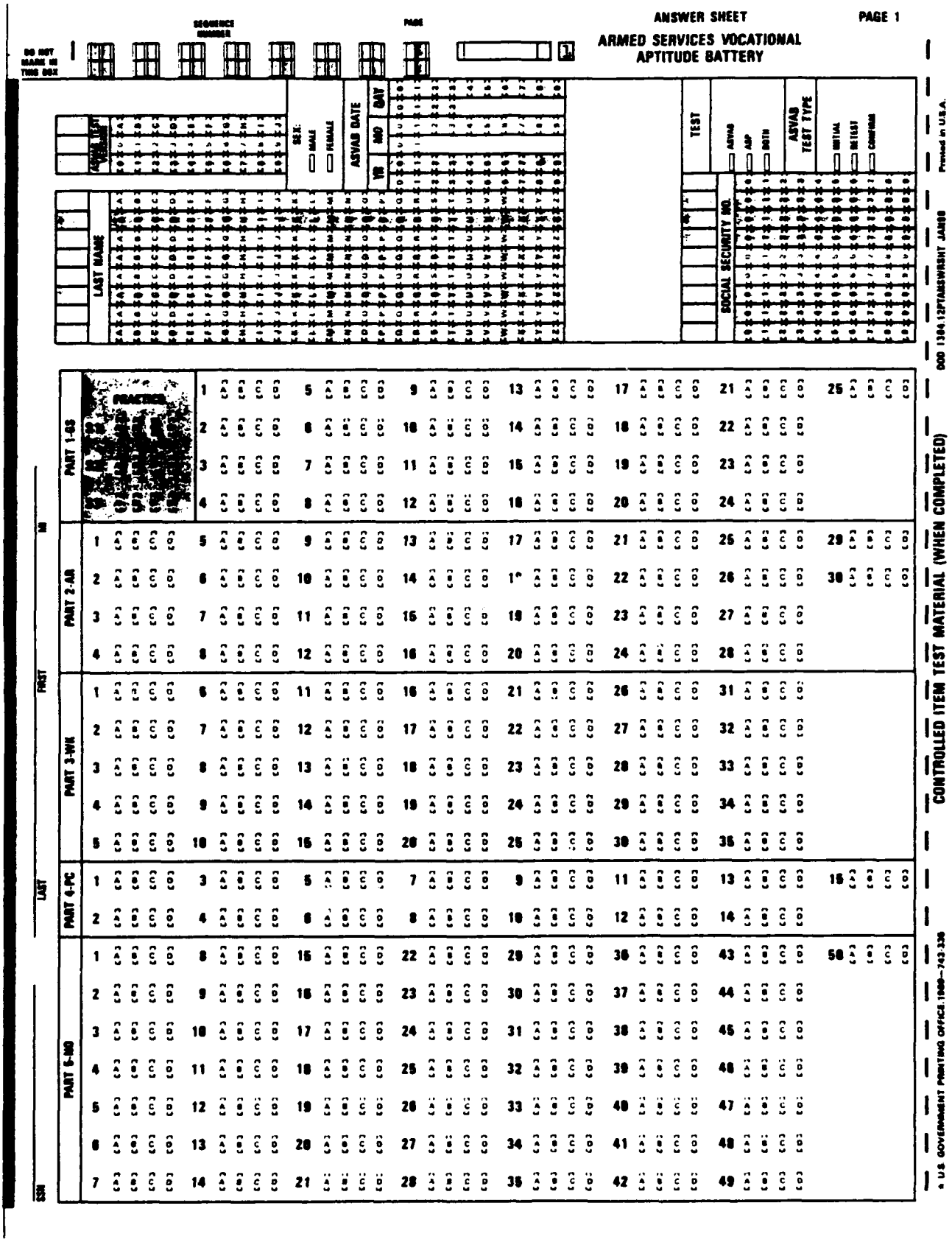

Figure 1. Discontinued Vertical-Response Answer Sheet for the Enlistment ASVAB (Page 1, Reduced)

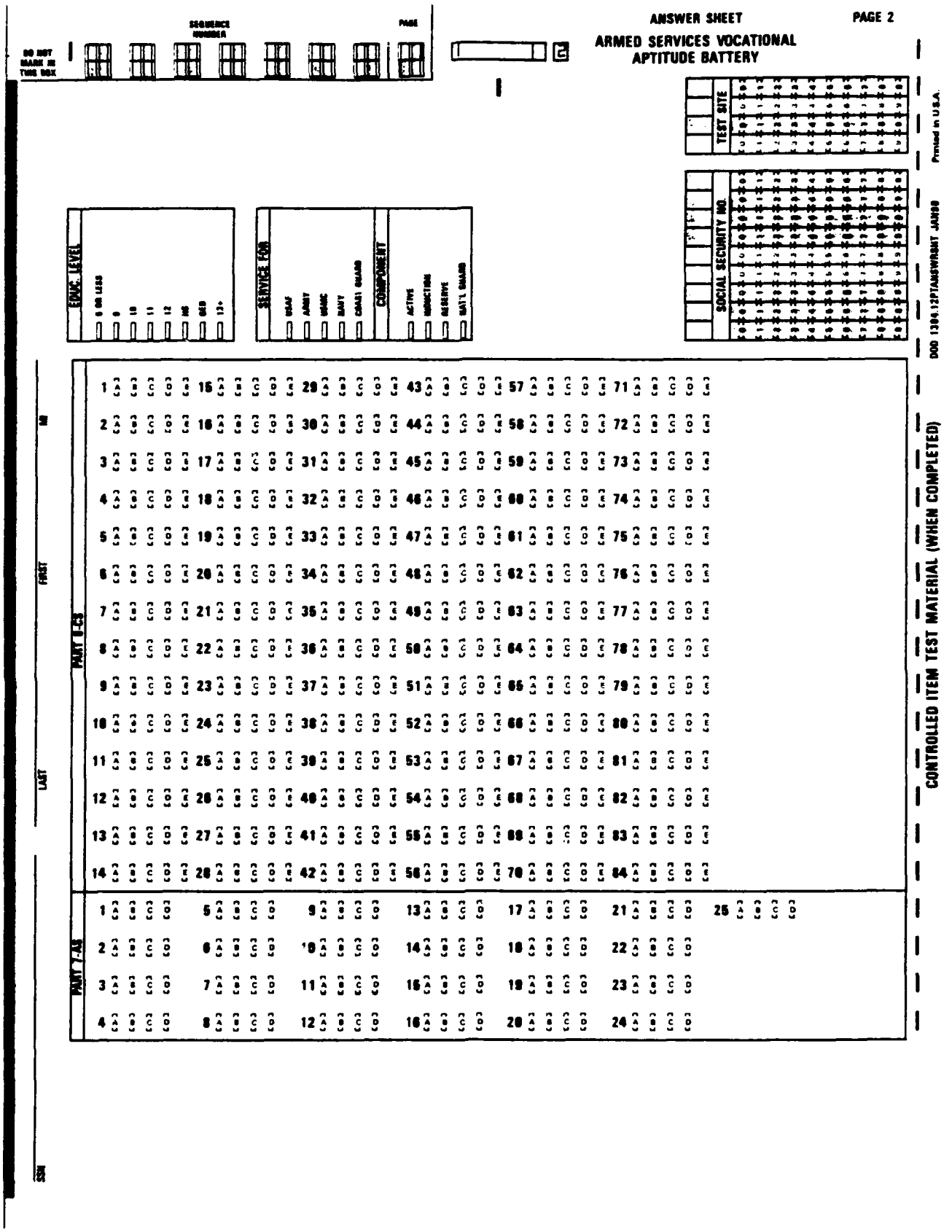

Figure 1. Discontinued Vertical-Response Answer Sheet for the Enlistment ASVAB (Page 2, Reduced)

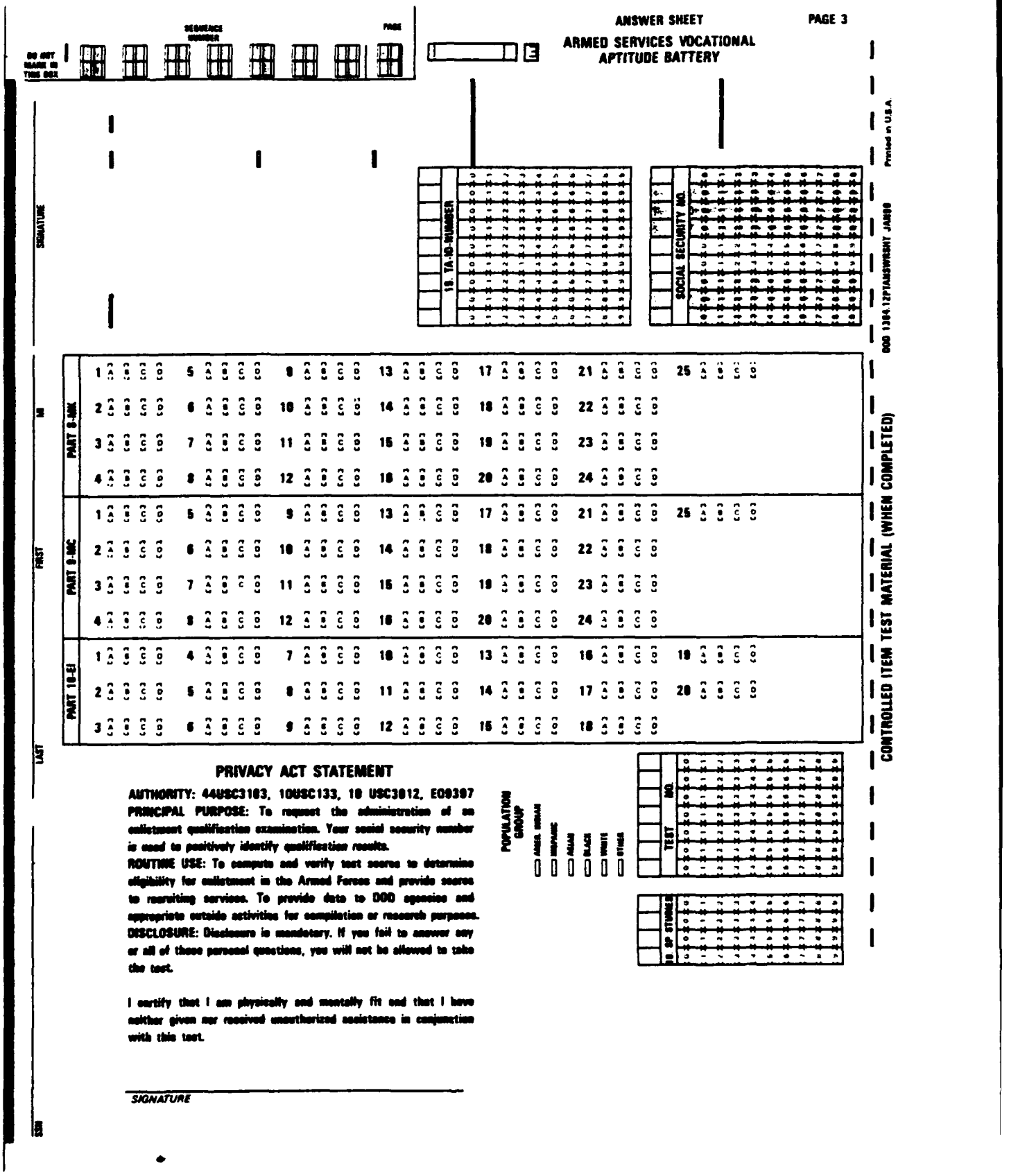

Figure 1. Discontinued Vertical-Response Answer Sheet for the Enlistment ASVAB (Page 3, Reduced)

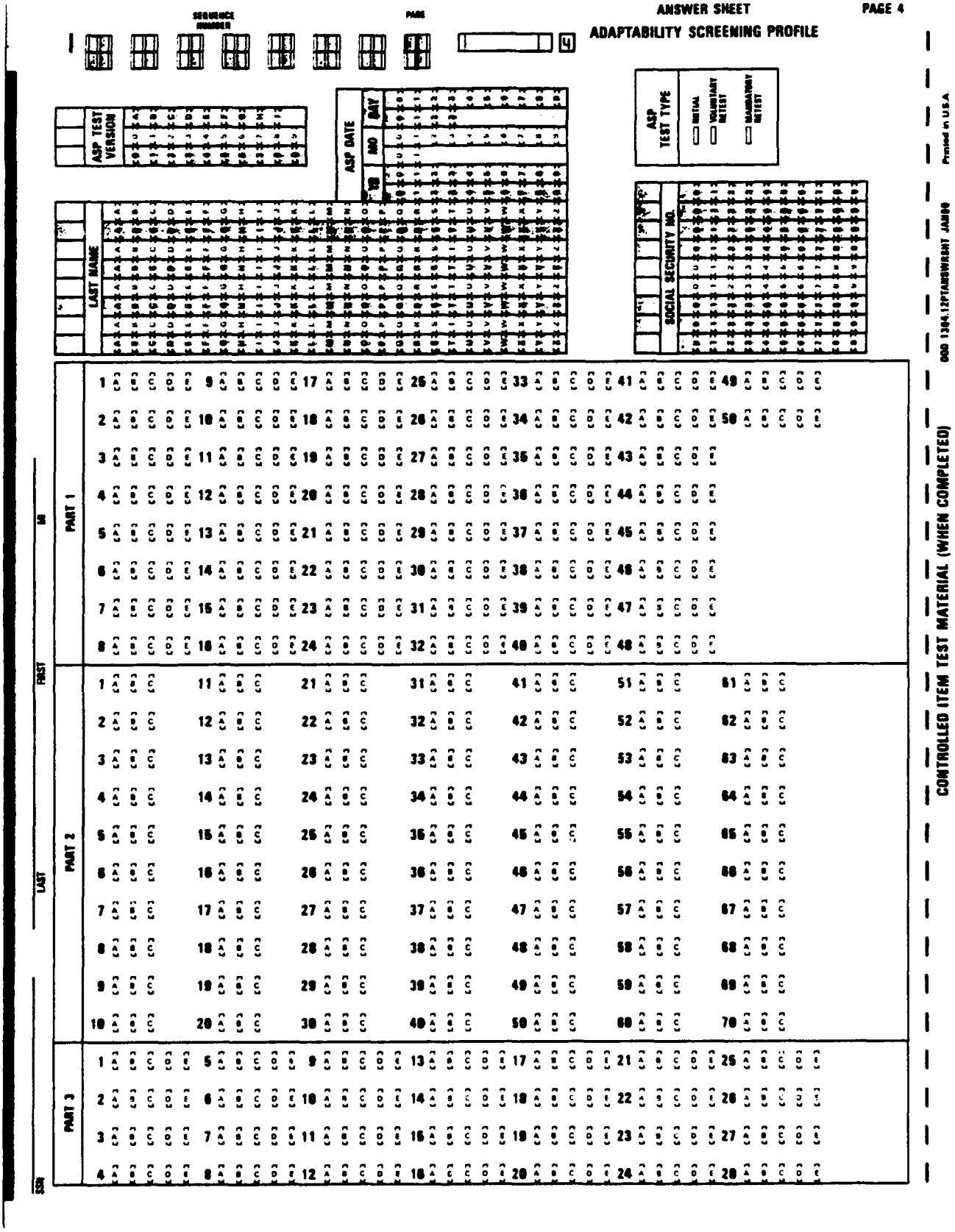

Figure 1. Discontinued Vertical-Response Answer Sheet for the Enlistment ASVAB (Page 4, Reduced)

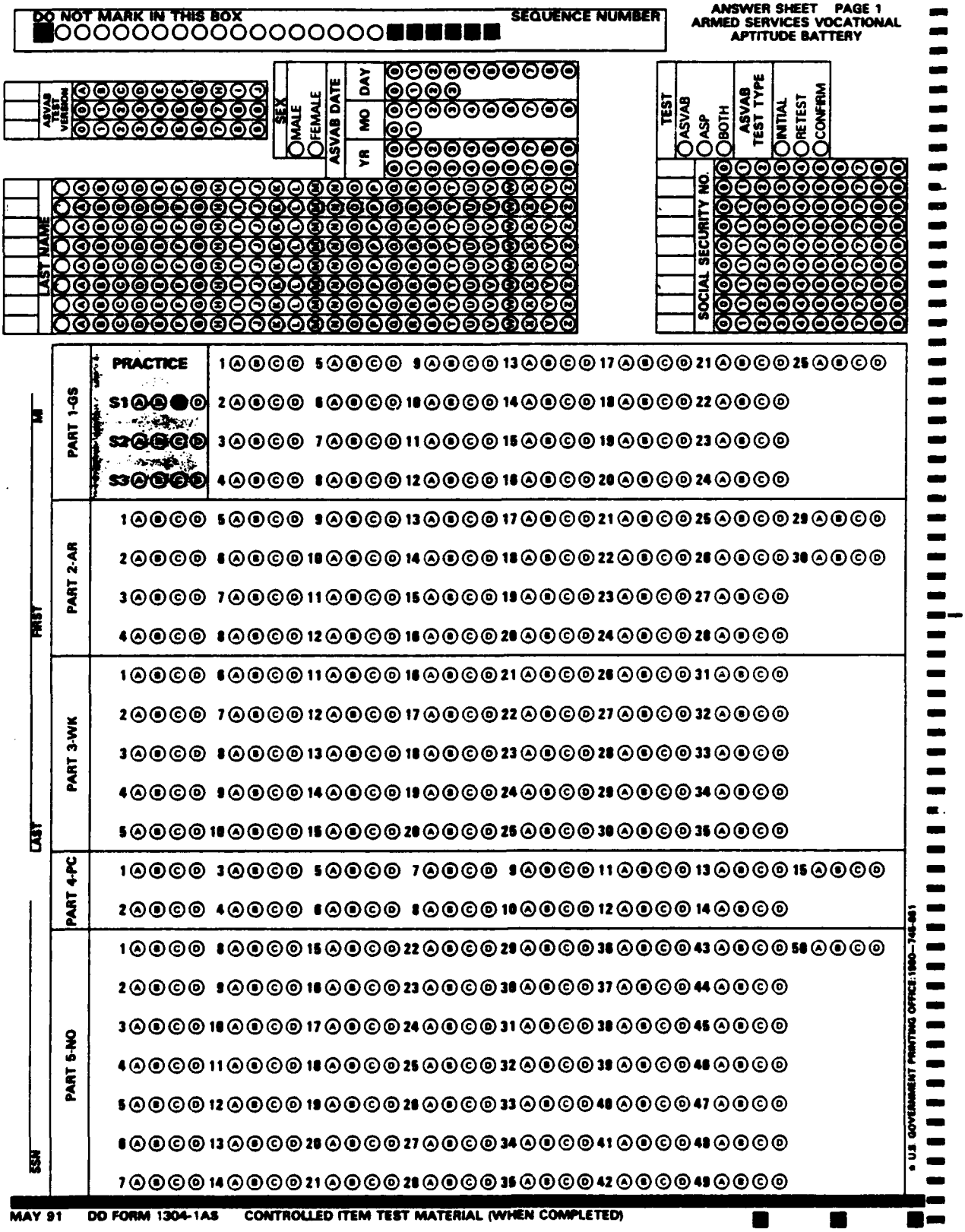

Figure 2. Circular-Response Answer Sheet for the Enlistment ASVAB (Page 1, Reduced)

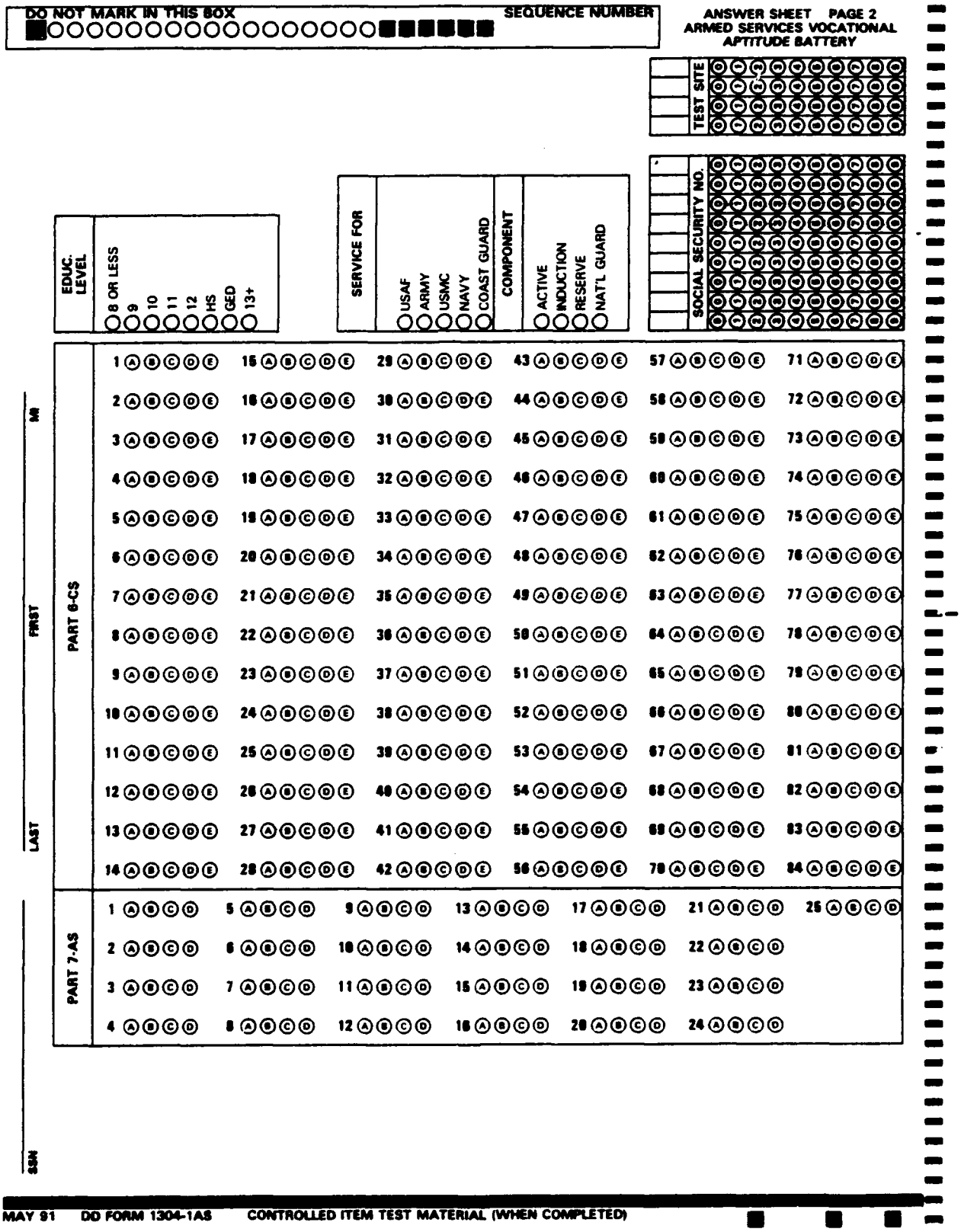

Figure 2. Circular-Response Answer Sheet for the Enlistment ASVAB (Page 2, Reduced)

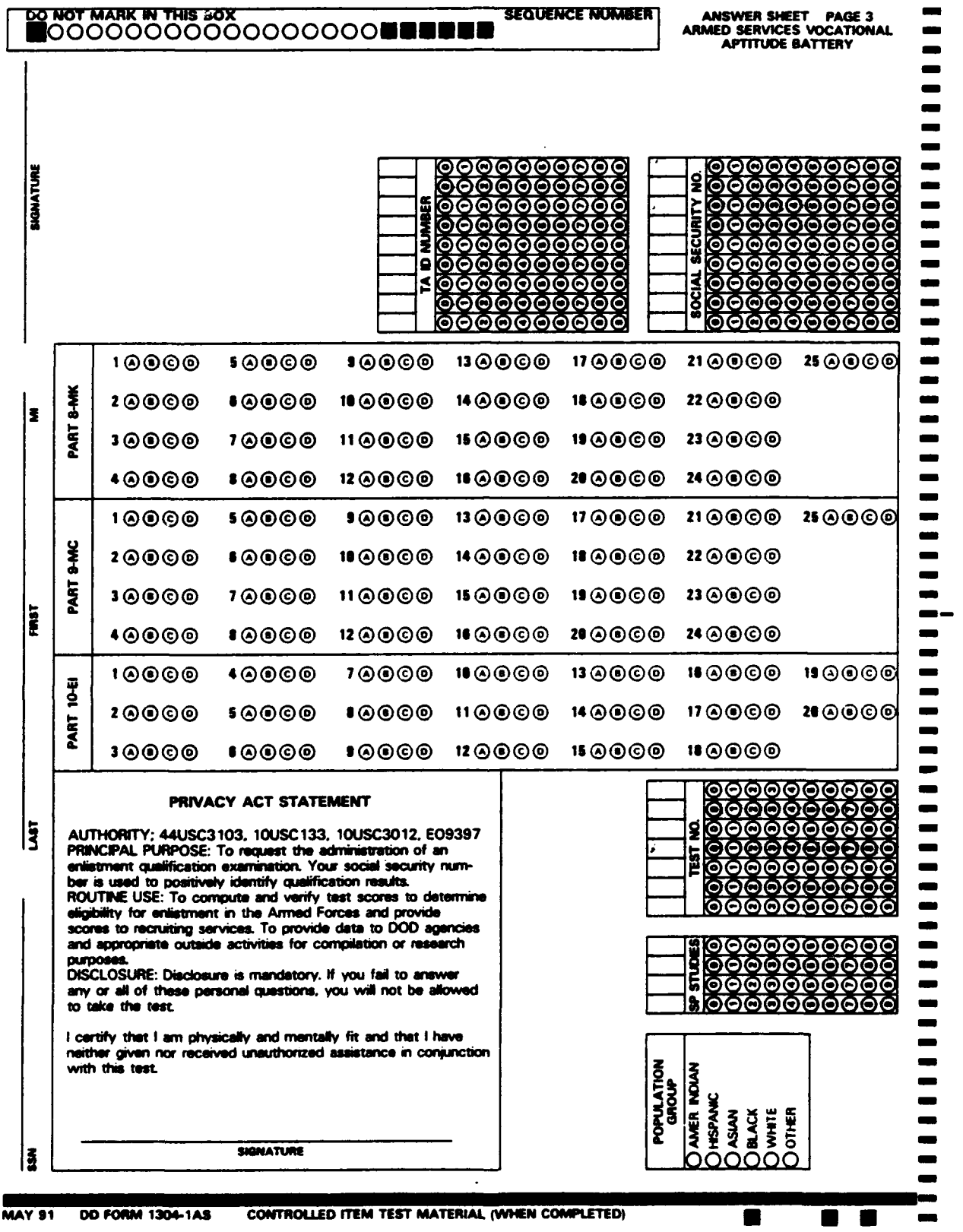

Figure 2. Circular-Response Answer Sheet for the Enlistment ASVAB (Page 3, Reduced)

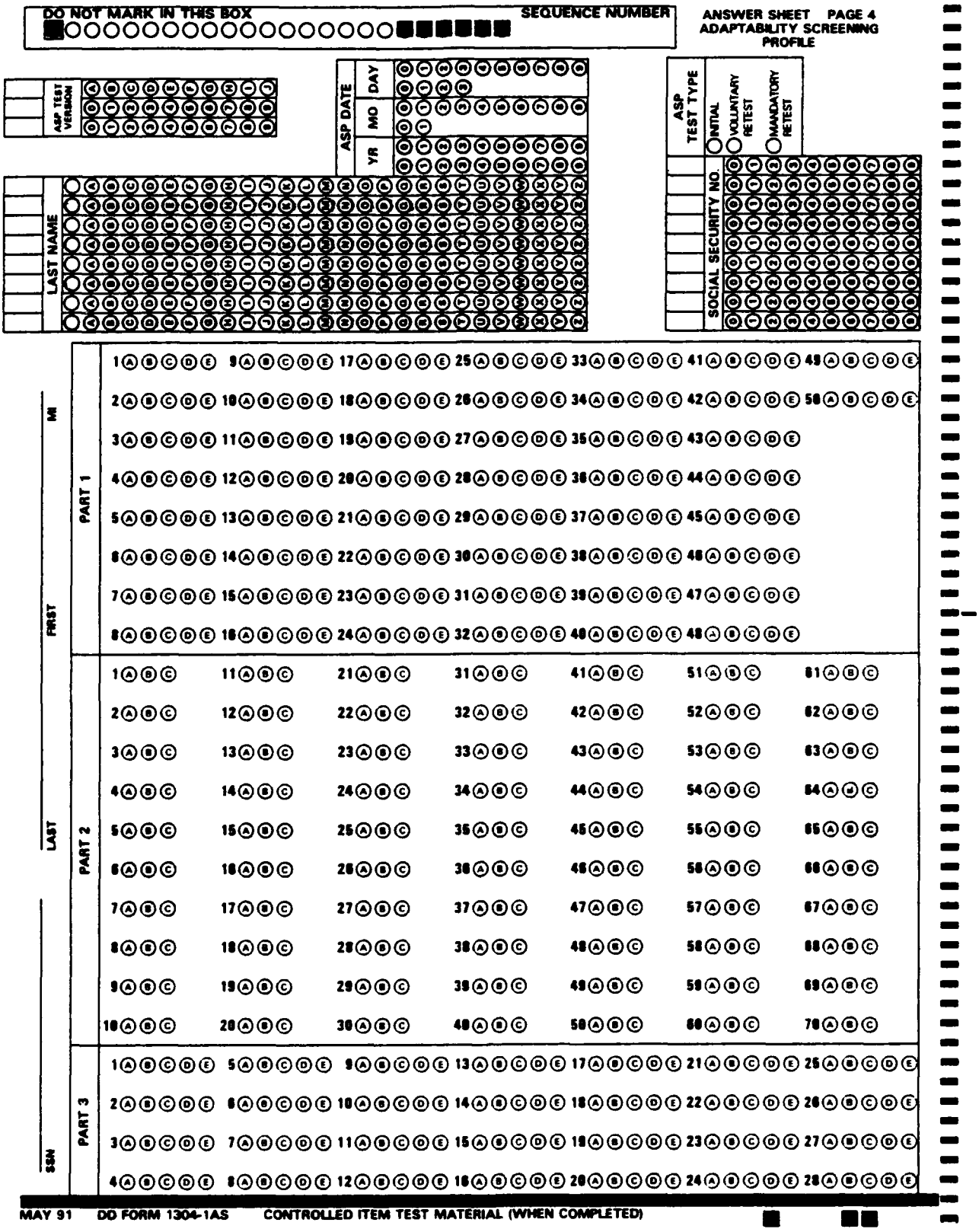

Figure 2. Circular-Response Answer Sheet for the Enlistment ASVAB (Page 4, Reduced)

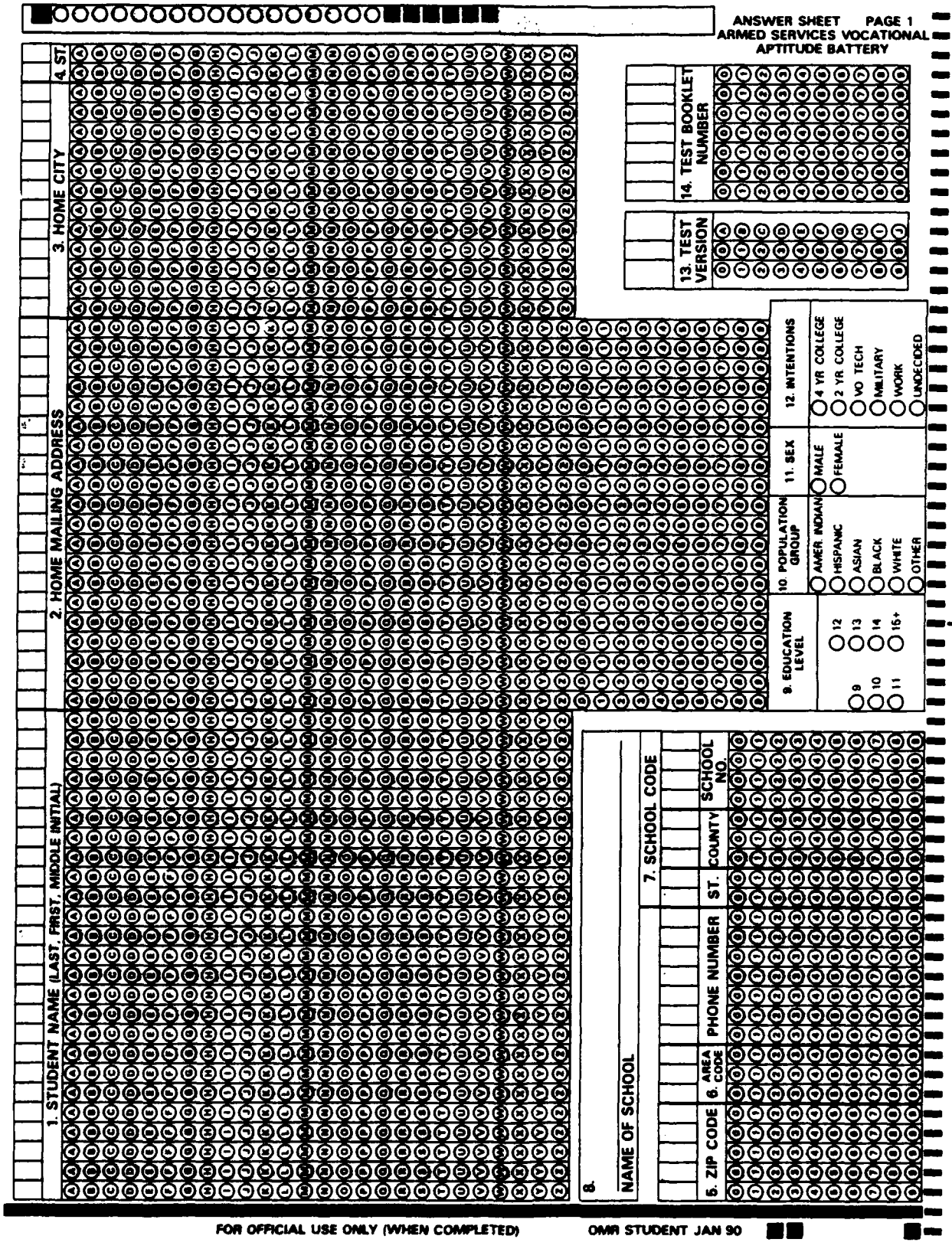

Figure 3. Circular-Response Answer Sheet for the Student ASVAB (Page 1, Reduced)

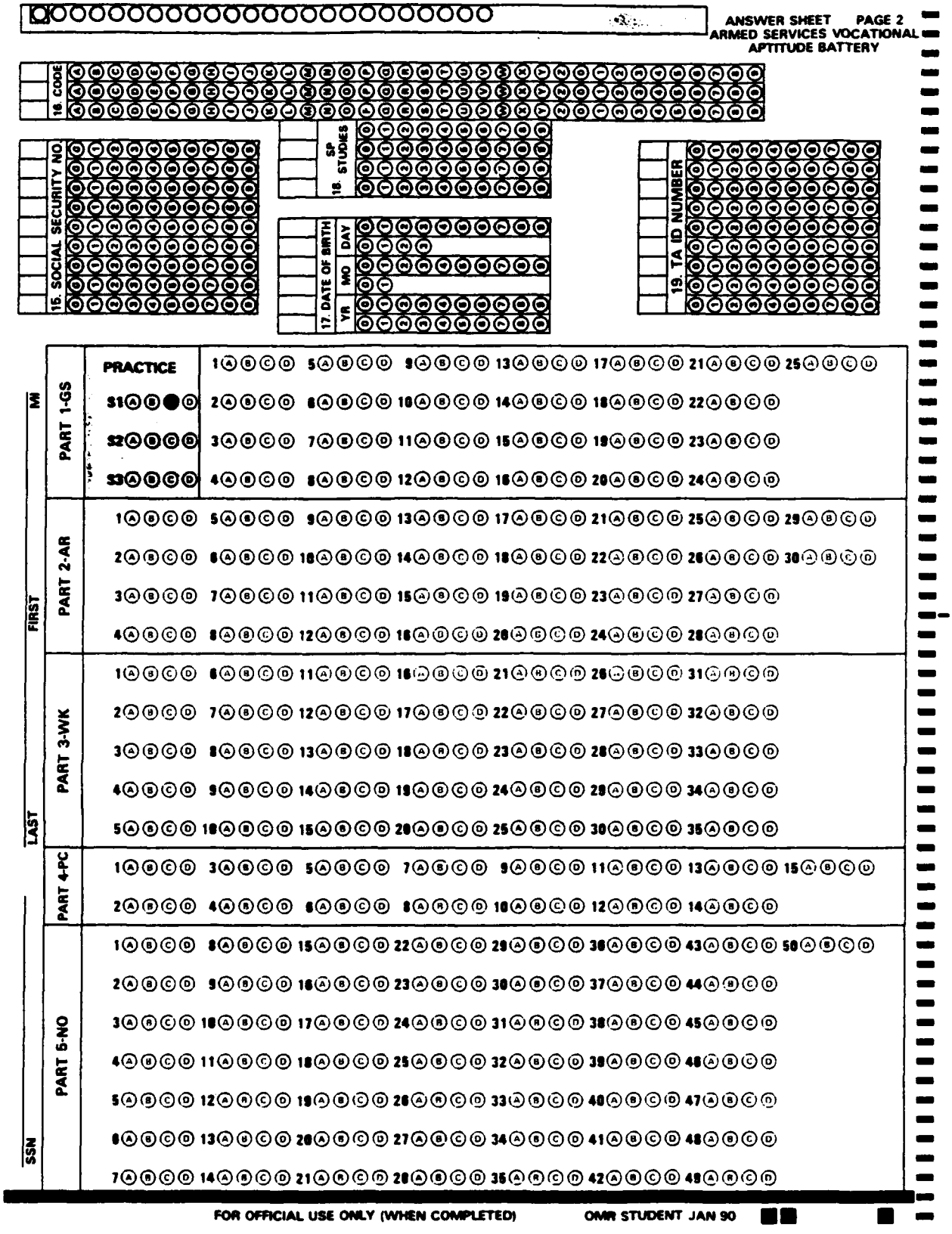

Figure 3. Circular-Response Answer Sheet for the Student ASVAB (Page 2, Reduced)

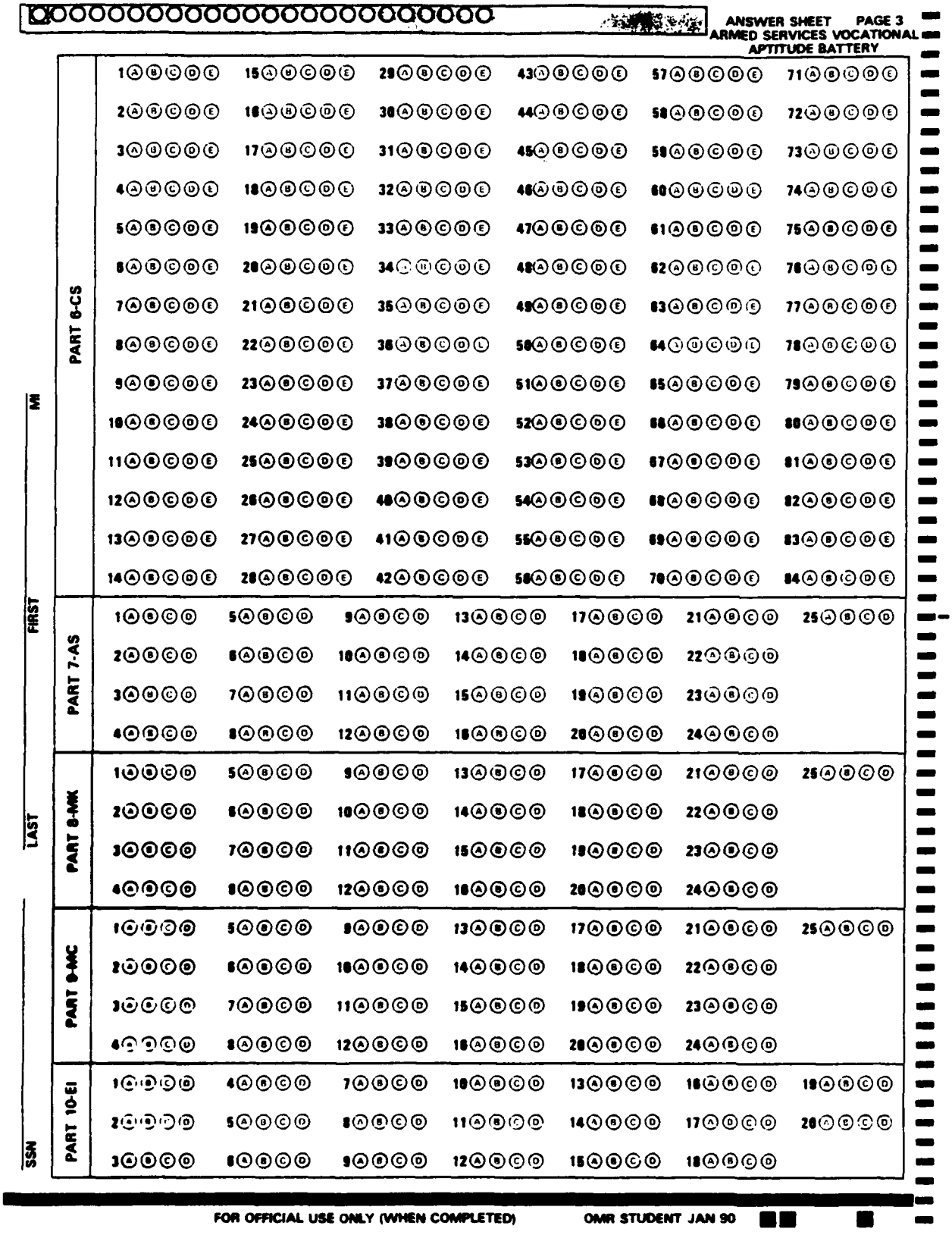

Figure 3. Circular-Response Answer Sheet for the Student ASVAB (Page 3, Reduced)

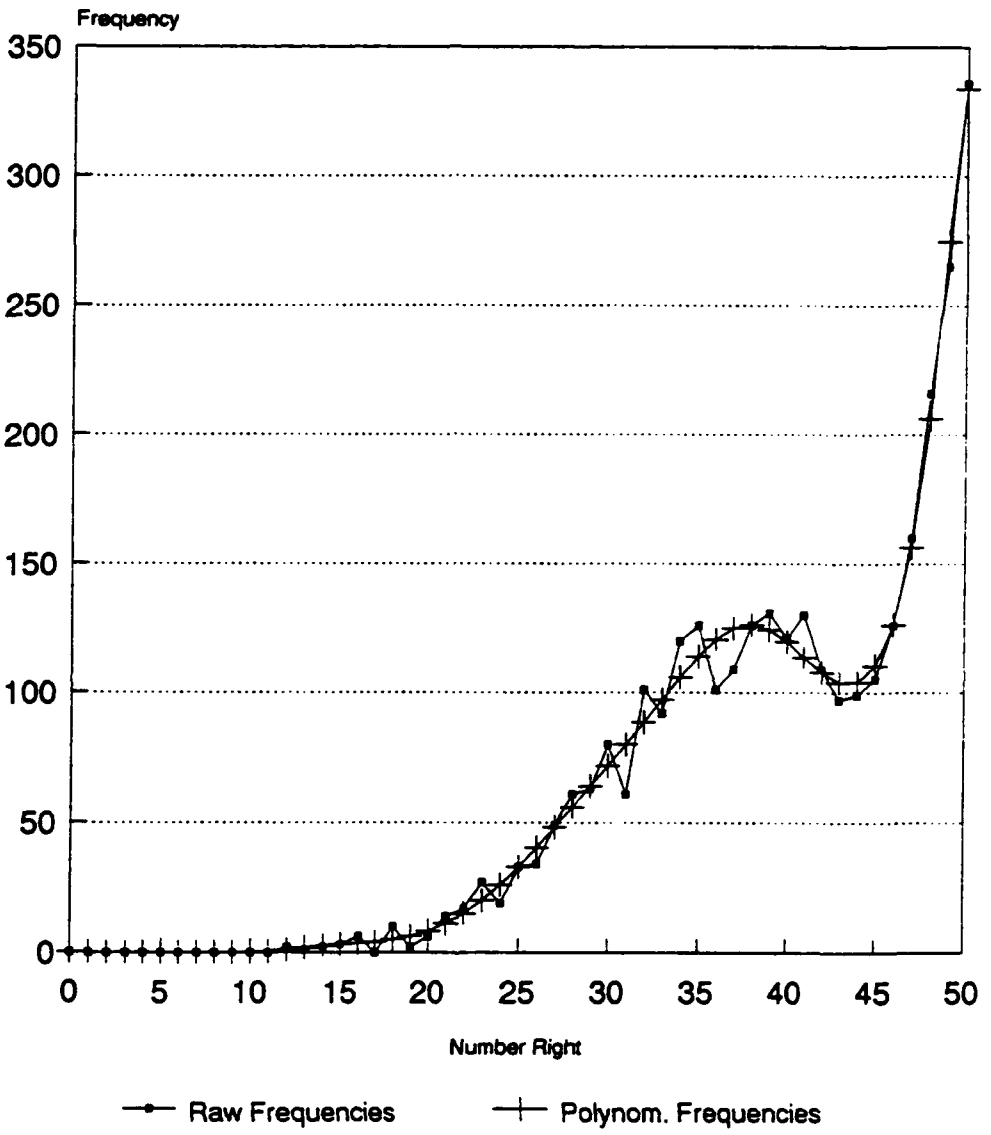

Figure 4. Raw and Polynomial Log-Linear Smoothed Frequency Distributions for Numerical Operations on the Circular-Response Answer Sheet

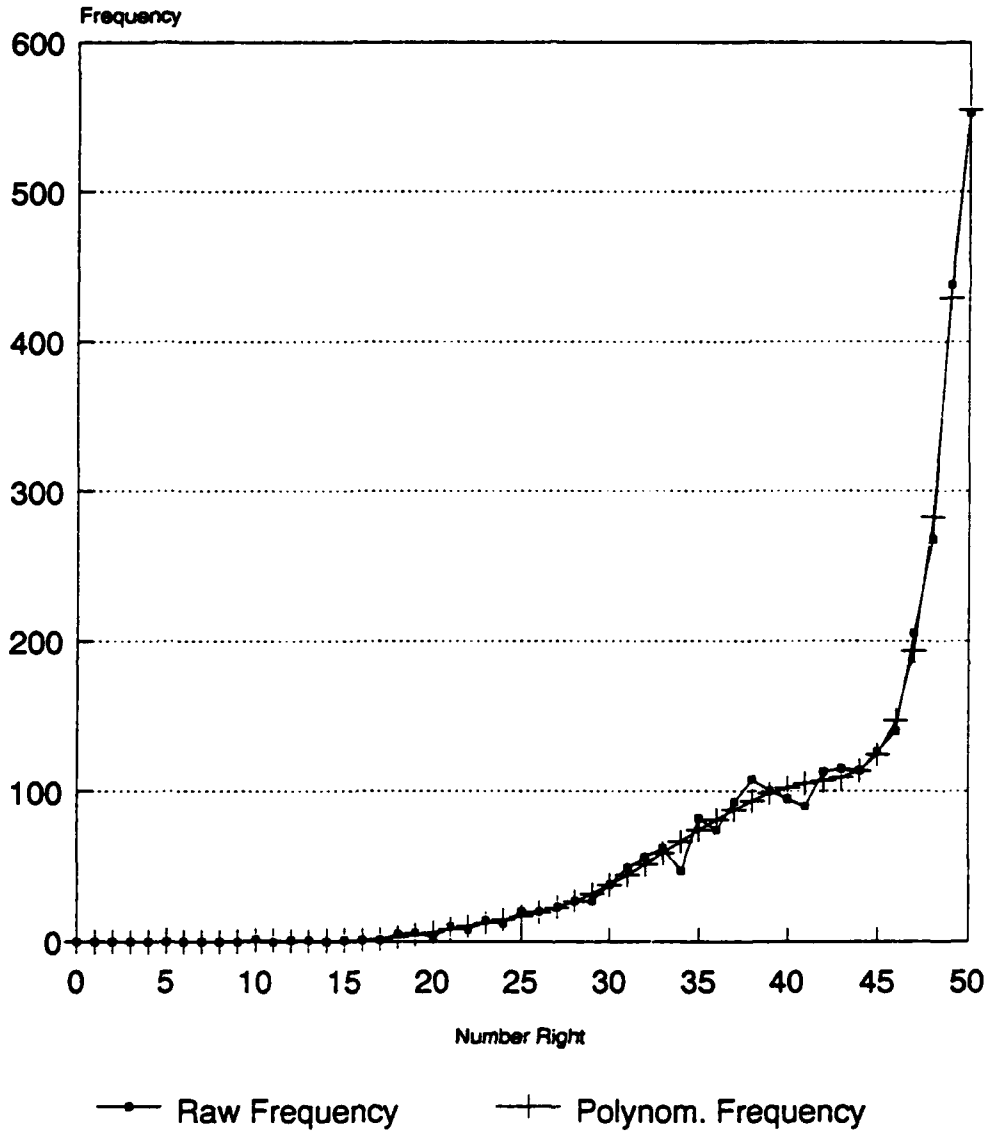

Figure 5. Raw and Polynomial Log-Linear Smoothed Frequency Distributions for Numerical Operations on the Vertical-Response Answer Sheet

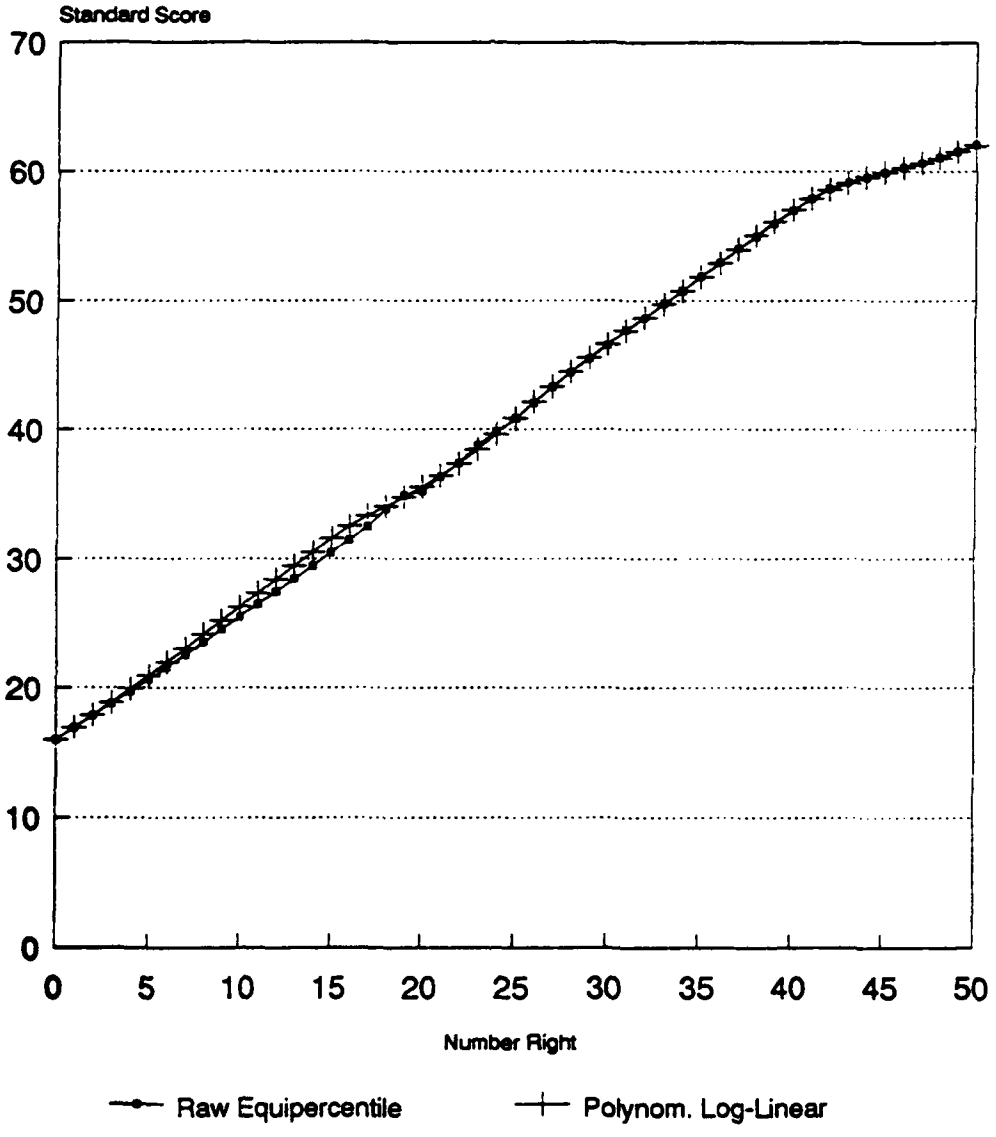

Figure 6. Raw and Polynomial Log-Linear Equipercentile Equatings of the Circular-Response Answer Sheet to the Vertical-Response Answer Sheet, for Numerical Operations

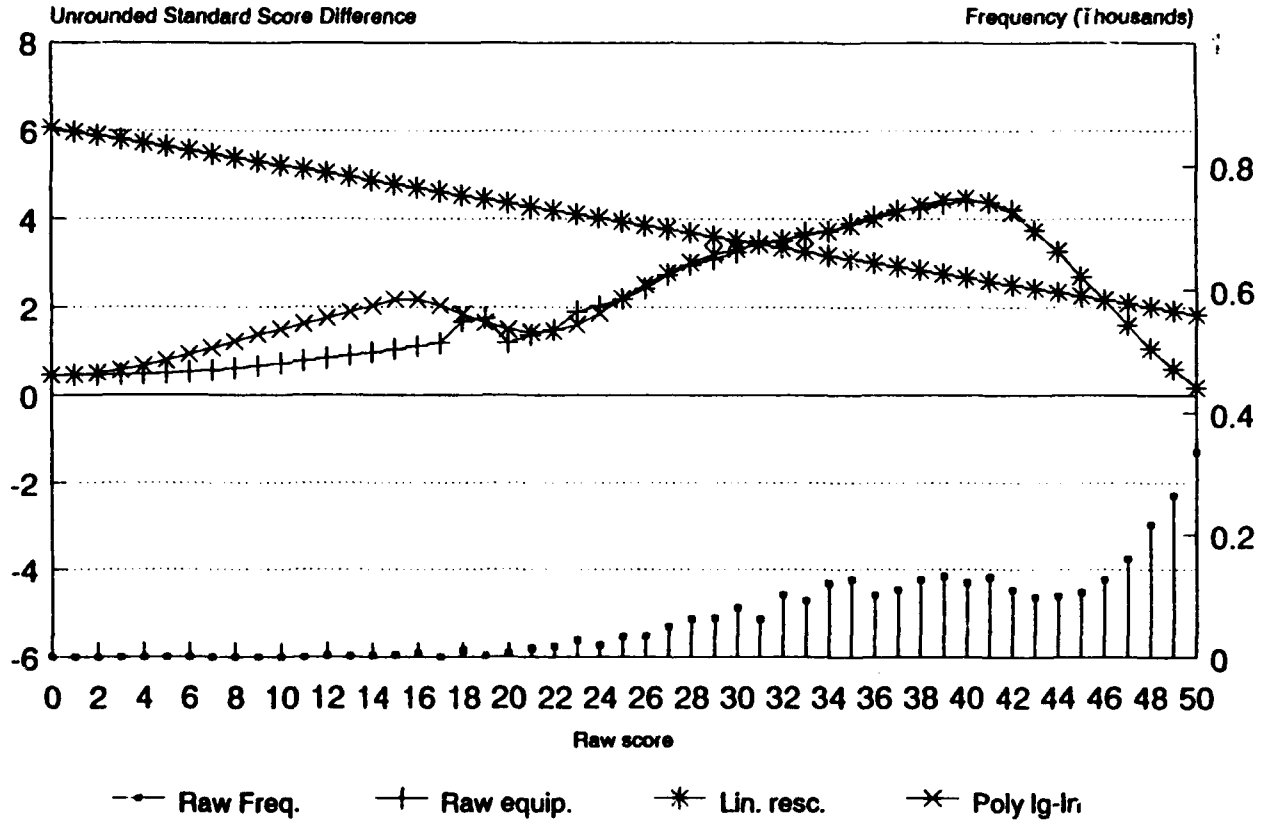

Figure 7. Comparison of Linear Equating, Raw Equipercentile Equating, and Polynomial Log-Linear Equipercentile Equating with Identify Equating, for Numerical Operations

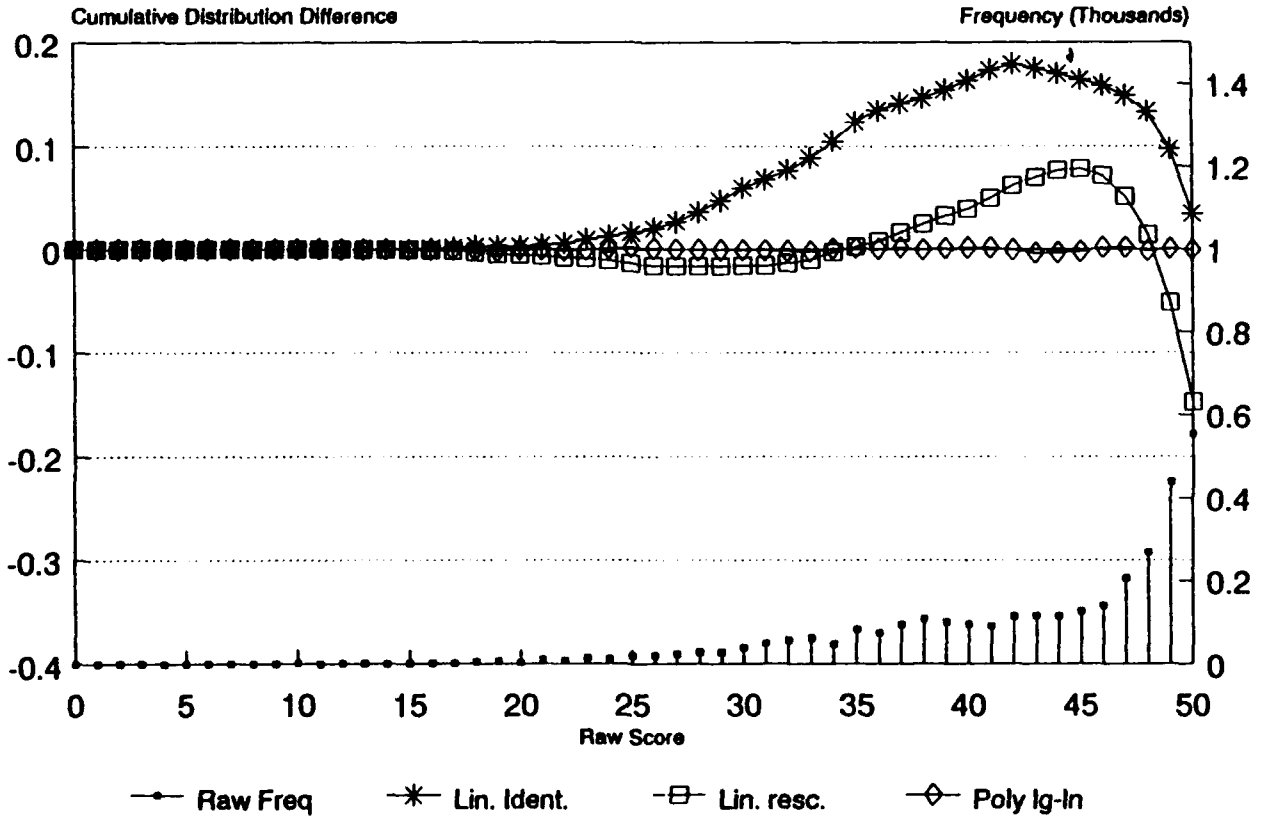

Figure 8. Comparison of Cumulative Distributions of Equated Scores from Circular-Response Answer Sheet and Cumulative Distribution from Vertical-Response Answer Sheet, for Numerical Operations

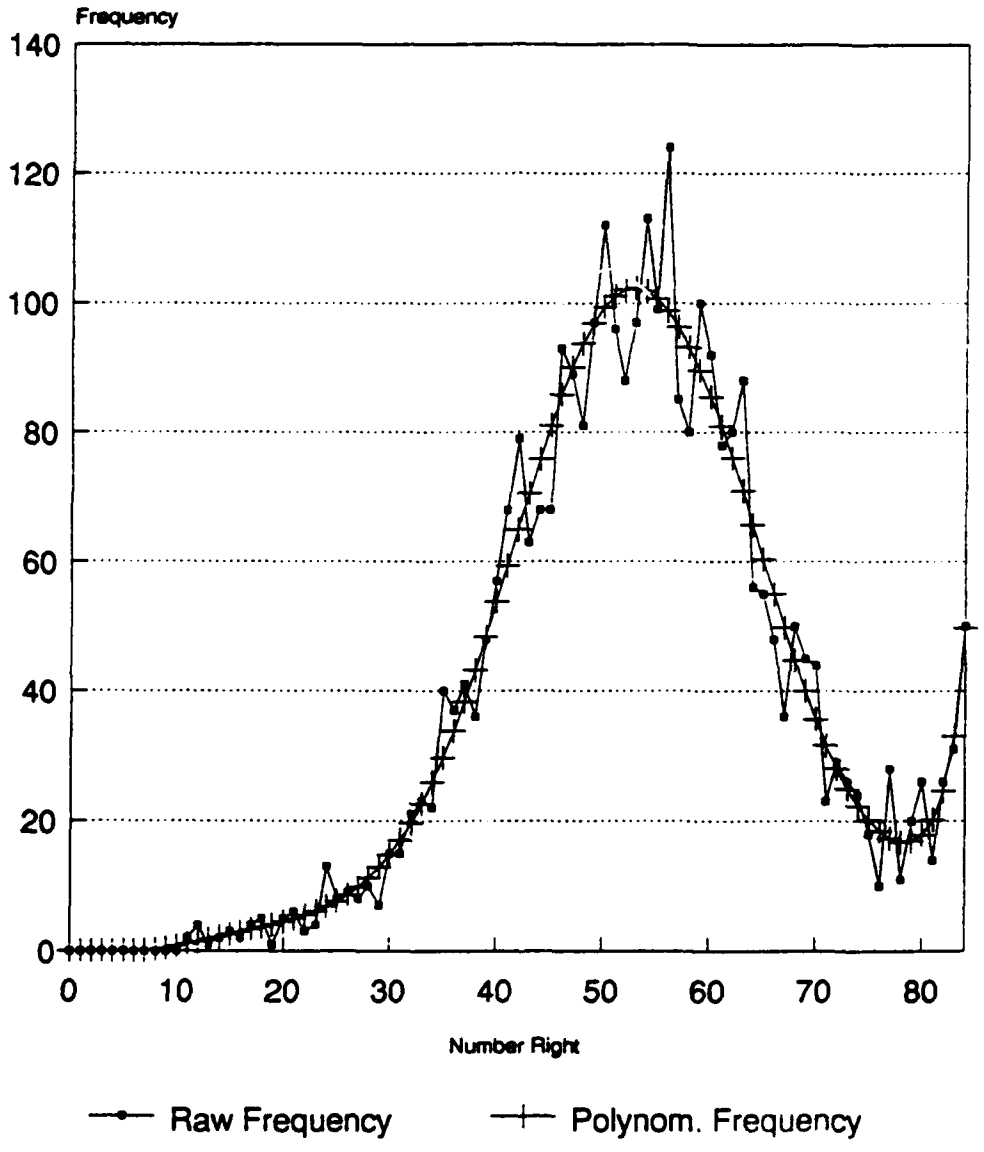

Figure 9. Raw and Quartic Log-Linear Smoothed Frequency Distributions for Coding Speed on the Circular-Response Answer Sheet

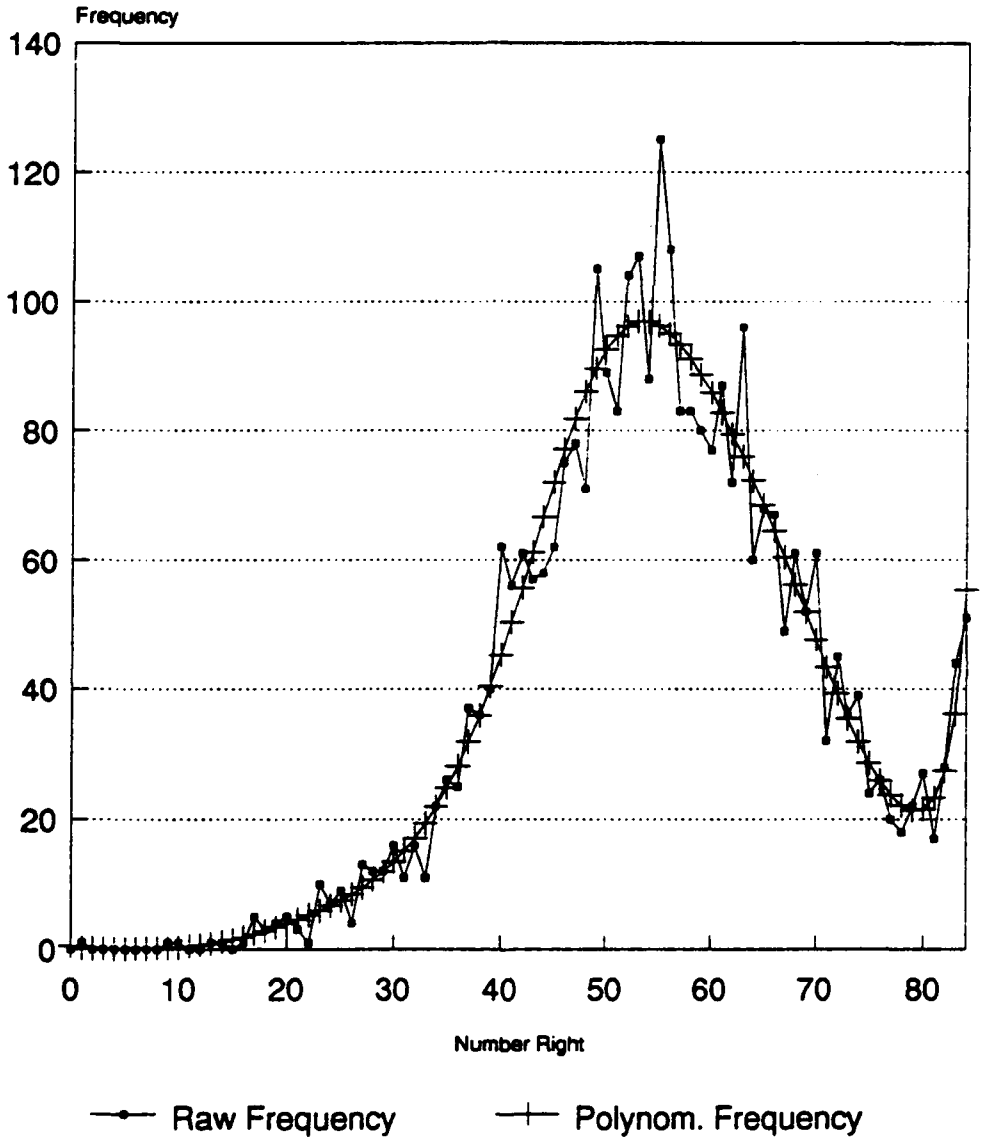

Figure 10. Raw and Quartic Log-Linear Smoothed Frequency Distributions for Coding Speed on the Vertical-Response Answer Sheet

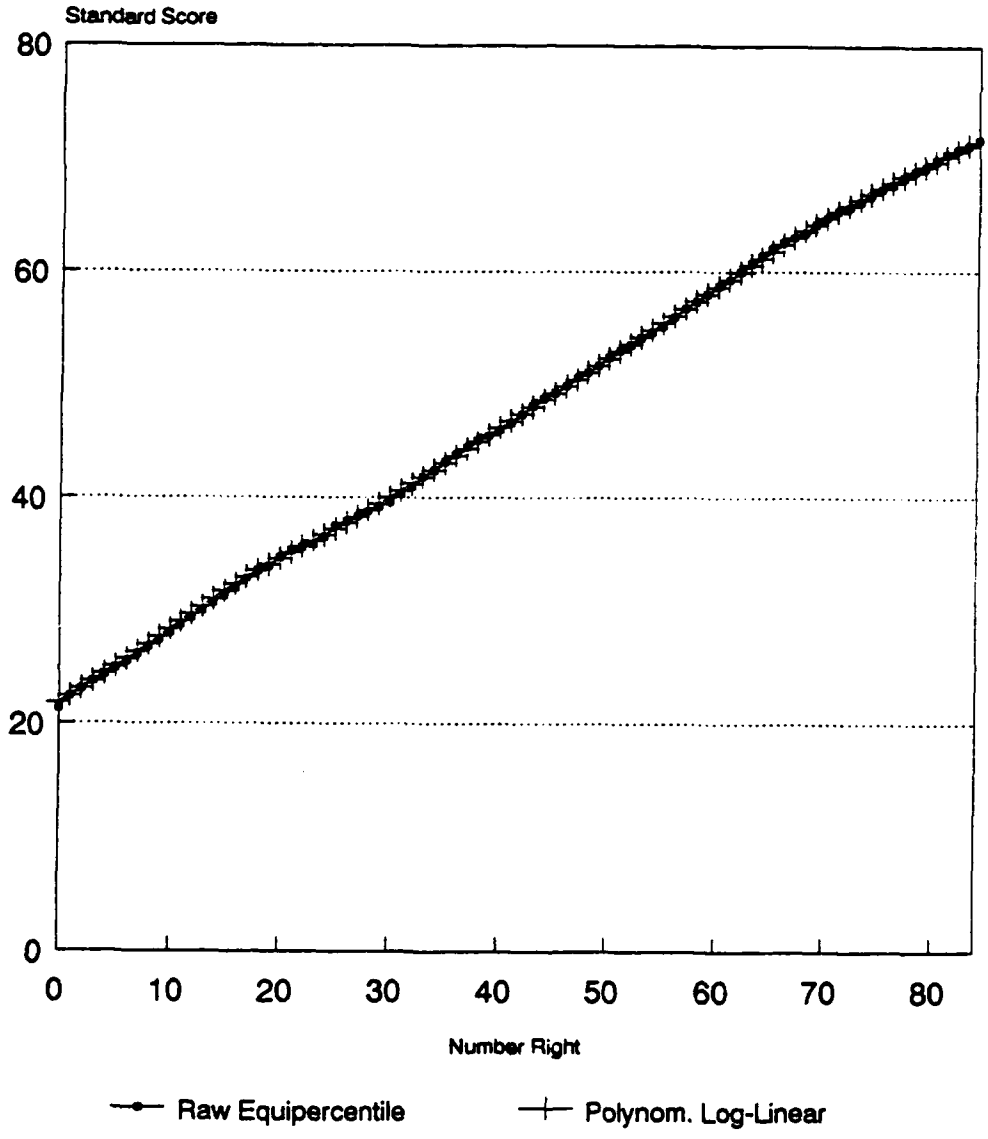

Figure 11. Raw and Quartic Log-Linear Equipercentile Equatings of the Circular-Response Answer Sheet to the Vertical-Response Answer Sheet, for Coding Speed

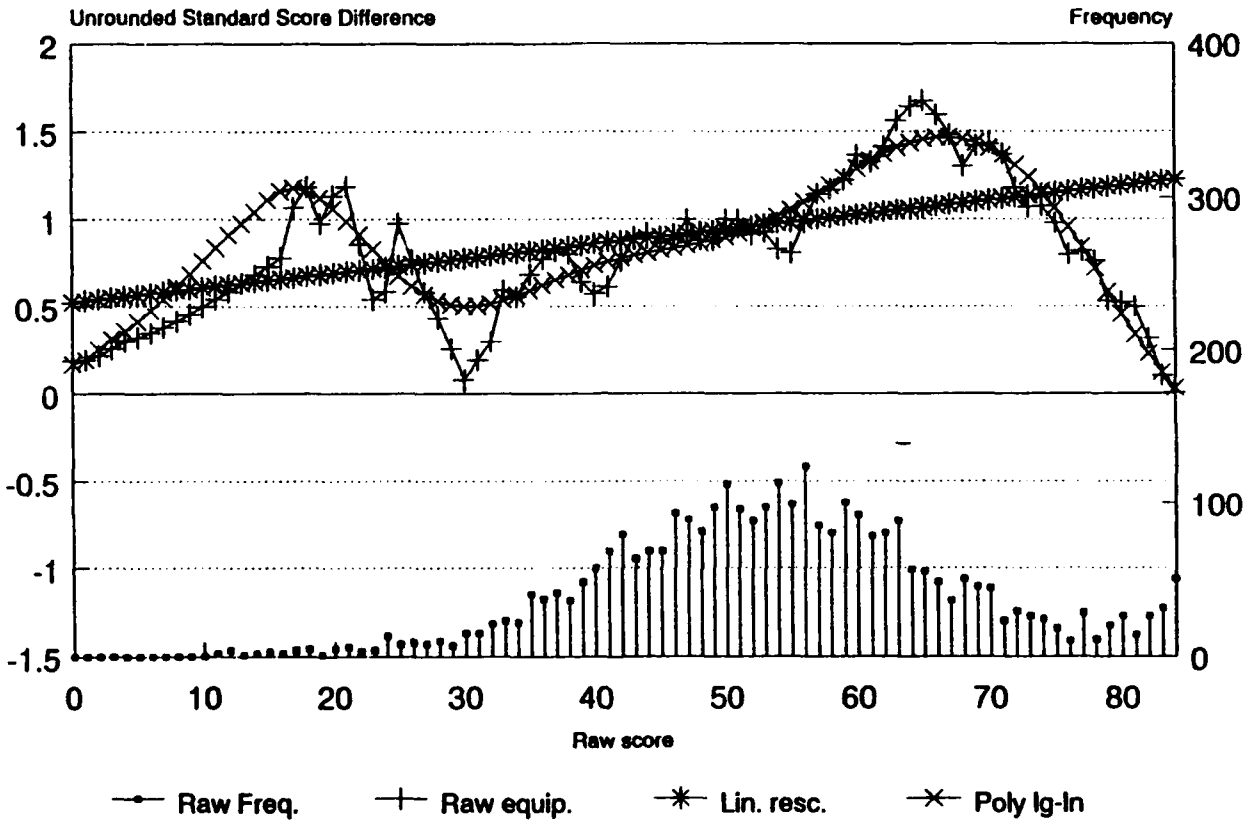

Figure 12. Comparison of Linear Equating, Raw Equipercentile Equating, and Quartic Log-Linear Equipercentile Equating with Identify Equating, for Coding Speed

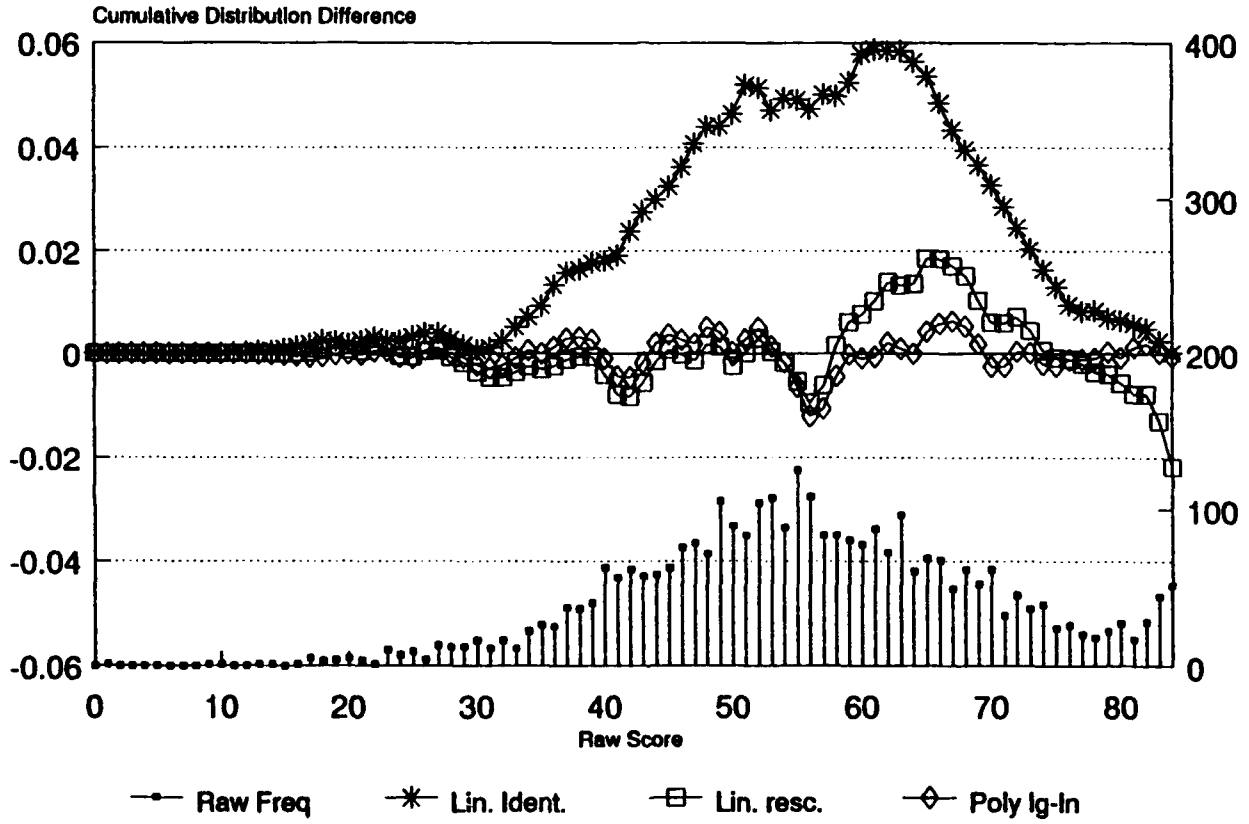

Figure 13. Comparison of Cumulative Distributions of Equated Scores from Circular-Response Answer Sheet and Cumulative Distribution from Vertical-Response Answer Sheet, for Coding Speed